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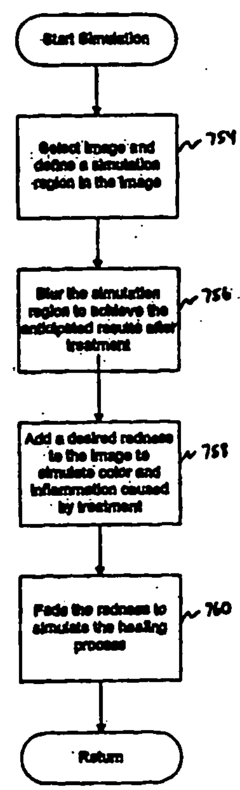
(54) Title: AESTHETIC IMAGING SYSTEM

(57) Abstract

Disclosed is an aesthetic imaging system (20) for use in editing digital images. The aesthetic imaging system includes an imaging program (21) that runs on a personal computer (28) having an image capture board (30), a monitor (32), a video source (34) for providing digital images to be edited by the aesthetic imaging system, and a pen and tablet (38) for use in editing the images. The imaging program includes a unique combination draw tool that includes a freehand draw mode, a curve mode and an undo mode that are available without cycling through menus. The combination draw tool may be used with any of the draw tools. Another feature of the imaging program is autoblend, a rectangular user interface that is invoked by each of the shape tools. The autoblend interface simplifies editing when using shape tools by consolidating the move, paste and blend, and paste without blending commands into a single, convenient interface.



AESTHETIC IMAGING SYSTEM

Relationship to Other Applications

This application is a continuation-in-part of U.S. patent application Serial No. 08/406,201, filed March 17, 1995, and U.S. patent application Serial No. 08/617,439, filed March 18, 1996, the benefit of the filing of which is hereby claimed under 35 U.S.C. § 120.

Field of the Invention

This invention generally relates to computer imaging programs and, more specifically, to a method and apparatus for manipulating digital photographs.

Background of the Invention

The digital age continues to present additional opportunities for visual communication using computers. As an example, digital photographs are routinely being manipulated to produce a desired effect or result in the magazine and film-making industries. In the medical field, computer-based imaging has and continues to gain acceptance in a clinical setting as a viable communications tool between plastic or "cosmetic" surgeons and potential patients.

People are with increasing frequency consulting physicians about cosmetic surgery. While in many cases the patients considering cosmetic surgery have an impressive understanding of the procedures available and medical terms used to describe these procedures, it is apparent that the slightest miscommunication may result in dire consequences. This has promoted the use of computer imaging to facilitate communication between the physician and prospective patient. Specifically, high-end aesthetic imaging systems allow a physician to take pre-operative digital images of the patient, e.g., including profile and frontal views. The images are stored

physician's changes. It is therefore difficult for the physician to show various combinations of the edits that had been performed. For example, a physician may edit an image to remove wrinkles around a patient's eyes and to narrow the patient's nose. Existing aesthetic imaging programs only allowed the physician to simultaneously show all of these changes. If, for example, the patient wished to view the changes to the eyes without the changes to the nose, it was difficult for the physician to easily separate out the sequence of edits that had been performed to adjust the patient's nose. An improved aesthetic imaging system in which a physician can more easily edit pre-operative images in response to a patient's suggestions and inquiries would be extremely advantageous.

A still further disadvantage of existing aesthetic imaging systems is that the systems allow a physician to perform nearly flawless editing of a patient's image. Unfortunately, the edits performed by a physician on an aesthetic imaging system are often unobtainable results that cannot be achieved when actual surgery is performed. Unless the physician is especially skilled at using the aesthetic imaging system, it is difficult to show the patient achievable results, which typically fall within a range somewhere between the original patient image, and the optimum results as displayed by the edited image on the screen. It therefore would be advantageous to develop an aesthetic imaging system that allowed a physician to display more realistic results that are achievable through surgery.

Summary of the Invention

The invention is an aesthetic imaging system for use in editing digital images. The aesthetic imaging system includes a unique user interface that allows edits to be performed more efficiently and with less confusion to the patient.

In one aspect of the invention, a method of editing a digital image comprised of a plurality of color pixels in an aesthetic imaging system is disclosed. The aesthetic imaging system including a processor, a memory, a monitor, and a pen and cooperating tablet for controlling a cursor displayed on the monitor. The pen has a depressable tip and a side button, each of which include an on status and an off status, wherein the position of the pen tip relative to the tablet determines the position of the cursor on the monitor. The method comprises: (a) evaluating the following variables: (i) the status of the tip of the pen; (ii) the status of the side button on the pen; and (iii) movement of the pen tip relative to the tablet; (b) actuating a freehand drawing mode if a first set of variables are present, wherein movement of the pen relative to the tablet edits pixels that are located at positions corresponding to the

menu bar. Only the commands and the outline of the menu bar are presented in a contrasting color, minimizing the overall visual impression created by the menu bar.

In yet another aspect of the invention, a warp tool is described that allows a user to quickly and easily manipulate various features in an image. To use the warp tool, a user first encircles a portion of the image to be edited. Once the area has been selected, the user may tip the pen to designate a stretch point within the selected area. As the user floats the pen over the tablet, the image is then stretched as if pulled from the stretch point. Areas of the image in the direction of stretch are compressed, and areas away from the direction of stretch are expanded. Areas surrounding the warping area are automatically adjusted to ensure that there is no discontinuities with the warping area. The manipulation of the image is performed in real-time, allowing a patient to see the warping as it is being performed by a user.

In accordance with still another aspect of the invention, a number of modules are provided to allow the user to improve the quality of an image, to analyze an image, or to prepare an image for meetings and presentations. A color correction module allows the color of an original image to be closely matched with the color of a target image. An orientation correction module allows the size and orientation of an original image to be closely matched with the size and orientation of a target image. A measurement module allows angles, distances, areas, and proportions to be measured and recorded on an image for presentation to a patient or colleagues. And a label module allows structures in a patient's image to be linked to textual descriptions. The modules greatly improve the ability to compare two images or maintain accurate records of achievable surgical results.

In accordance with yet another aspect of the invention, a module is also provided that simulates the effect of laser resurfacing treatment on a patient. The module accurately portrays the image of the patient immediately following surgery, the image of the patient during the healing process, and the image of the patient when the patient has fully healed.

An advantage of the tools, features, and modules described herein are that they improve the overall experience of a patient during a preoperative visit with a physician. The powerful tools in the aesthetic imaging system allow the physician to easily manipulate the patient's image in response to feedback provided by the patient. The aesthetic imaging system interface also allows the patient to focus on the image being manipulated, rather than on the aspects of the aesthetic imaging system that allow the manipulation. The end result is an improved preoperative visit that provides

FIGURE 11 is a pictorial representation of a user interface for implementing the autoblend tool of FIGURE 10;

FIGURE 12A is a flow chart of an exemplary routine illustrating a cutout tool in accordance with the invention;

FIGURE 12B is a flow diagram of an exemplary routine illustrating a rotate tool in accordance with the invention;

FIGURE 13 is a flow chart of an exemplary routine for viewing images in accordance with the invention;

FIGURES 14A-14D are pictorial representations illustrating the effects of a compare feature in accordance with the invention;

FIGURES 15A-15C illustrate a split image option of viewing images in accordance with the invention;

FIGURE 16 is a pictorial representation illustrating the use of a translucent image to allow a patient to accurately position themselves in order to capture a second image having the same location and orientation as an original stored image;

FIGURE 17 is a pictorial representation illustrating a compare image wherein a presurgical image of a patient is compared side-by-side with a postsurgical image having the same location and orientation;

FIGURES 18A-18C are pictorial representations illustrating the use of a warp shape tool to edit a patient's image;

FIGURES 19A-19E are pictorial representations illustrating the function of the warp tool;

FIGURE 20 is a pictorial representation illustrating the use of a transparent menu bar when viewing an image of a patient;

FIGURE 21 is a flow chart of an exemplary routine for implementing a zoom viewing feature in accordance with the invention;

FIGURES 22A-22D are flow charts of exemplary routines for implementing a number of modules that may be used to optimize an image for presentations or display;

FIGURE 23 is a pictorial representation illustrating the use of a color correction module in accordance with the invention;

FIGURE 24 is a pictorial representation illustrating the use of an orientation correction module in accordance with the invention;

FIGURES 25A-25D are pictorial representations illustrating the use of a measurement module in accordance with the invention;

Indianapolis, Indiana. The buffers are discussed in regard to a single pose only, such as a profile or front view of a person.

The original image buffer 50 contains an unedited digital image, for example, a side profile picture of a potential patient. The modified image buffer 52 contains any edits made to a copy of the original image. The modified image buffer is updated during a save and after each session. The current image buffer 54 contains information identical to the modified image buffer upon beginning a session. Thereafter, edits made to the current image are saved in the working buffer 56 as an overlay to the current image. During a save, the contents of the current image buffer 54 are copied to the modified image buffer 52, and the working buffer 56 is cleared.

Prior to discussing the aesthetic imaging system in further detail, a compendium of terms used in the application may be helpful:

Image	A digital photograph or picture of a patient.
Stylus	The "pen" that may be used to select menus, modify images, and carry out other commands in the program. The stylus controls the cursor, just as a mouse pointing device does on a personal computer.
Tablet, or Pad	The electronic notepad used in conjunction with a stylus. The pen must be held relatively close to the pad in order for the pen to communicate with the tablet. Unlike a mouse, the tablet follows an X / Y grid that matches the monitor, i.e., if the pen is positioned at the top left corner of the tablet, the cursor is displayed at the top left corner on the monitor.
Floating	Moving the pen to move the cursor, without actually touching the tablet.

wants to load an image (picture) from computer storage, e.g., a hard drive. If the Storage option was selected, the image(s) to be edited or viewed during the current session are selected at block 70.

At block 72, the selected images are copied to the appropriate buffers in the frame grabbing board, as described in FIGURE 2 and the accompanying text. For example, if the selected image is an original image that has not yet been edited, the original image will be copied to the original, modified, and current image buffers. If the selected image is an image that has previously been modified, the original image is copied to the original image buffer 50 and the modified image is copied to both the modified and current image buffers 52 and 54. It will be appreciated that the number of images that may be loaded at one time will be limited, in part, by the capacity of the frame grabbing board. The program then loops to block 62.

If the Storage option was not selected, a test is made at block 74 to determine if the *Draw* option has been selected from the main menu. If the Draw option has been selected, a draw tool routine is called at block 76. The program then loops to block 62. A suitable routine for implementing the Draw option is shown in FIGURE 5.

If the Draw option was not selected, a test is made at block 78 to determine if the *Shape* option has been selected. If the Shape option has been selected, a shape tool routine is invoked at block 82. A suitable routine for implementing the Shape option is shown in FIGURE 10. Otherwise, at block 82 a test is made to determine if the *View* option has been selected.

If the View option has been selected, a view subroutine is invoked at block 83. An appropriate routine for the View option is shown in FIGURE 13. The program then loops to block 62.

If the View option was not selected, a test is made of block 84 to determine if the *Modules* option has been selected. If the Modules option has been selected, a list of the modules available to the user is provided at block 85. Suitable routines for implementing the various modules are shown in FIGURES 22A-22D. If the Modules option is not invoked, the routine continues to a decision block 86.

At block 86 a test is made to determine whether the *Exit* option has been selected from the main menu. If not, the program loops to block 62. Otherwise, any edits to the image are saved at block 88. At this point in the program, the image in the current image buffer 54 is saved to the modified image buffer 52, and the working buffer 56 is cleared. The program then terminates.

monitor. Patients can thus easily align themselves with their former picture to achieve very similar before and after pictures.

The advantage of the translucent method of aligning a patient is shown in the side-by-side display shown in FIGURE 17. As shown in FIGURE 17, the aesthetic imaging system of the present invention may generate a side-by-side display of the two images to allow a patient to easily and accurately compare a presurgical picture with a post-surgical picture. The left half of the monitor may display the presurgical image 370, and the right half of the monitor may display the post-surgical image 372. Allowing a patient to view the two images side-by-side in precisely the same orientation provides the patient with an accurate impression of the results achieved by surgery.

Upon establishing a desired position for the patient, the image is focused and sized at block 102 by using the aesthetic imaging system to adjust the electronic controls on the video camera. After any adjustments have been made to the camera, at block 104 the tip of the pen is pressed anywhere on the tablet to freeze the digital image onto the monitor. At block 106, the user makes a determination if the image currently displayed on the monitor is acceptable. If the image is not acceptable, the routine loops to block 100. If the image is acceptable, an appropriate command is entered at block 108 and the image is stored in nonvolatile memory for future viewing.

At block 110, a test is made to determine if an exit or other similar command has been entered by the user, i.e., if any more pictures are to be taken. If additional pictures are to be taken, the program loops to block 100. Otherwise, at block 111 a checksum value (described below) is calculated by the imaging program for each (original) image that has been stored. At block 112, the imaging program stores each image and its associated checksum value. The routine then returns to block 68 of FIGURE 3.

II. Determining Authenticity Using Checksum Values

The checksum value is an addendum to an original stored image that is used to determine its authenticity when the image is subsequently displayed or printed. Those skilled in the art will recognize that there are a number of methods of implementing such a checksum procedure. For example, one checksum computation is to add up the grayscale values for one of the colors, i.e., red, green, or blue, for each pixel comprising the image. Assuming a screen of 640 by 480 pixels and 256 colors per pixel, the checksum values would range from 0 to (640)(480)(255). When an image

original image is acquired and when an image is to be displayed, or the comparison will be meaningless.

While the use of a checksum is contemplated in the exemplary routine for determining whether an original image has been altered, it will be appreciated that other techniques may be used to detect when an original digital image has been modified. For example, a flag or other marker may be uniquely associated with the original digital image. If the flag or other marker is absent from the digital image being displayed, the digital image is a copy that is presumed to have been changed. Alternatively, two versions of the image may be stored, included an unaltered original and a copy. The two images may be compared in order to determine whether modifications have been made to the copy.

The editing aspects of the invention are now described.

III. Editing Using Draw Tools

A disadvantage of prior art aesthetic imaging systems is that a physician or facilitator may have to cycle back and forth between several menus in order to properly edit an image. In an effort to minimize the number of menus required, the imaging program includes a unique combination draw (CD) feature that generally works with all of the drawing tools. The CD feature allows a user to freehand draw, use curves to edit an image, as well as undo using either freehand or curves, without having to invoke a separate menu for each item.

The following describes an interface for the CD feature as implemented in an embodiment of the invention. For purposes of this discussion, it will be assumed that the airbrush tool is selected as the drawing tool, although it is to be understood that the CD tool generally applies to all of the drawing tools. Upon selection of the airbrush draw tool, the aesthetic imaging system prompts the user to choose a color from a color palette that appears on the monitor. A color is selected using the pen. After selecting a color, a side bar menu is displayed. The user may select from a number of options on the side bar, including brush size and intensity, or select away from the side bar menu to remove the menu from the screen. In the latter case, the system defaults are used.

To freehand draw, the user presses on the tablet with the pen tip and continues pressure while moving or "rubbing" the pen on the tablet. At this point the chosen color is written onto the image at the location on the monitor that corresponds to the pen location. Pressing the side bar while repeating the motion will allow the user to selectively remove any edits to the image using a freehand motion.

was pressed against the tablet, the imaging program enters freehand draw mode, shown at block 130. In one embodiment of the invention, freehand draw mode is entered if the pen moves the equivalent of three or more pixels. While in freehand draw mode, freehand edits may be made to the image in a manner similar to prior art imaging programs. This mode will remain until pressure on the pen tip is released. After beginning freehand draw mode, the routine loops to block 124.

If the pen was not moved, e.g., the pen has been moved two pixels or less prior to releasing the tip, the imaging program begins a curve mode by establishing a first endpoint, as indicated at block 132, and drawing a line on the monitor from the endpoint to the current pen position, indicated at block 134. At block 136, a test is made to determine if the tip has been pressed. The imaging program at this point is looking for a second endpoint to be entered. If not, the program loops back to block 136 to await the input. As noted above, the user can go back to the beginning of the routine using the cancel button if the user has changed his or her mind, although this is not shown in the flow diagram. Specifically, the first cancel would place the routine at block 124, the second at either block 122 or 124, depending on the draw tool selected, and subsequent cancels would forward the routine to the main menu.

Once the tip is pressed, the second endpoint is established at the tip position, and a line segment is drawn on the monitor from the two endpoints, as indicated at block 138. At this point in the routine, the imaging program is in "curve draw mode" as indicated at block 140, and the user can make any edits desired using a curvilinear line segment having the established endpoints. The routine loops to block 124 while in this mode.

With reference to block 124, if the side button has been depressed a test is made at block 142 to determine if the imaging program is in either the freehand or curve draw modes. If the imaging program is in either mode, an undo mode will be invoked as long as the side button remains depressed, as indicated at block 144. If at the time of depressing the side button the imaging program is in freehand draw mode, the undo will also be freehand. Selective freehand undo edits are thus available. Similarly, if at the time of depressing the side button the imaging program is in curve draw mode, the undo will be in this mode. Selective "undo" edits are then available using a curve, as opposed to freehand drawing. Releasing the side button will return the imaging program to the drawing mode that was active just prior to depressing the side button.

	Step S4	select airbrush;
	Step S5	move pen to curve;
	Step S6	select curve;
	Step S7	select an airbrush color;
	Step S8	move pen to the first anchor point position;
	Step S9	select at the position to establish the anchor point 136;
	Step S10	move pen to the second anchor point position;
	Step S11	select at the position to establish the anchor point 138;
	Step S12	move pen to bend the curve 134 into the bridge of the nose;
FIGURE 7B:	Step S13	press the side button on the pen to exit to the main menu;
	Step S14	move pen to draw;
	Step S15	select draw;
	Step S16	move pen to airbrush;
	Step S17	select airbrush;
	Step S18	move pen to freehand;
	Step S19	select freehand;
	Step S20	select a color for the airbrush tool;
	Step S21	use a rubbing motion with the pen to make the freehand edit;
FIGURE 7C:	Step S22	press the side button on the pen to exit to the main menu;
	Step S23	move pen to draw;
	Step S24	select draw;
	Step S25	move pen to undo;
	Step S26	select undo;
	Step S27	move pen to curve;
	Step S28	select curve;
	Step S29	use a rubbing motion with the pen to undo the previous edit;

In accordance with the invention, the steps required to perform the same edits using the aesthetic imaging system 20 are now described. With reference to FIGURE 8A-8E, the steps required to perform the edits include:

FIGURE 8A:	**Step N1**	move pen to draw;
	Step N2	select draw;
	Step N3	move pen to airbrush;
	Step N4	select airbrush;
	Step N5	elect any color for the airbrush tool
	Step N6	move pen to the first anchor point position;
	Step N7	select at the position to establish the anchor point 136;
	Step N8	move pen to the second anchor point position;
	Step N9	select at the position to establish the anchor point 138;
	Step N10	move pen to bend the curve 134 into the bridge of the nose;
FIGURE 8B:	**Step N11**	pressing the tip of the pen against the tablet and use a rubbing motion to make the freehand edit.
FIGURE 8C:	**Step N12**	pressing the tip of the pen and the side button simultaneously, and maintain pressure while rubbing in the area to be undone;
FIGURE 8D:	**Step N11**	move pen to the first anchor point position;
	Step N12	select at the position to establish the anchor point 142;
	Step N13	move pen to the second anchor point position;
	Step N14	select at the position to establish the anchor point 144;

to be augmented. Edits made in block 206 are saved at block 208 by pressing and then releasing the tip of the pen. The program then terminates.

FIGURES 9B-9C further describe the operation of the contour tool, by illustrating how pixels are replicated from one area of an image to another. The image areas described are for exemplary purposes only, and are simplified for clarity in this discussion. With reference to FIGURE 9B, an area 209 of an image is comprised of red 218R, green 218G, blue 218B, and yellow 218Y areas separated by boundary lines 210, 212, 214, and 216. It is assumed that a pair of anchor points 218 and 219 have been established by a user along the boundary 212, wherein the aesthetic imaging system will display a line segment 220 between the two anchor points.

In FIGURE 9C, it is assumed that the user has moved the midsection of the line segment 220 to the right. In this instance, the blue area 218B has been stretched into the yellow area 218Y. This area is bounded by the line segment 220 (now curved) and the boundary line 214. Also, the green area 218G has been stretched into the blue area 218B. This area is bounded by a curved line segment 221 and the boundary line 212. The red area 218R has expanded into the green area 218G; this area is bounded by a curved line segment 222 and the boundary line 210.

If the opacity level is at 100 percent, the newly defined areas will be comprised of the color being expanded. Thus, the area bounded by segments 220 and 221 will be blue; the area bounded by segments 221 and 222 will be green; and the area bounded by segment 222 to the left edge of the diagram will be red.

If the opacity level is less than 100 percent, pixels from the underlying image areas that are being written over by the newly defined areas will be blended into the newly defined areas. At an opacity of 80 percent, for example, the area bounded by segments 220 and 221 will still be primarily blue, but the portion of this area bounded by the segment 220 and the boundary line 214 may have a yellow tinge; and the portion of this area bounded by the boundary line 212 and segment 221 may have a green tinge. As the opacity percentage is dropped, the effects on these areas will be even greater.

While somewhat simplistic, the illustration in FIGURES 9B and 9C describes the function of the contour tool and the effect on more complicated pixels patterns will be appreciated by those skilled in the art. The area bounded by segment 220, boundary line 214, segment 221, and boundary line 212 will not be affected by changes in the opacity setting.

illustrated in an effort to further detail options available for a given tool, and may be especially helpful for those unfamiliar with imaging packages.

Copy, Cutout, Resize	Stretch, Rotate	Freeze Compare
●	●	●
●	●	●
●	●	●
•	•	•
Zoom	Zoom	Zoom
Undo	Undo	Undo
Compare	Compare	Split image
Split image	Split Image	
Inverse	Inverse	
Blend	Blend	

The black dots are brush size options that allow a user to choose the thickness of a shaping tool. The zoom option allows a user to look at an image in greater detail. When the zoom option is invoked, the aesthetic imaging system displays a square overlaid on the image. The square can be positioned by the user with the pen. After positioning the square, that area of the image will be magnified when the pen is selected. Canceling with the pen will display normal viewing mode. The undo option allows a user to undo edits to an image. The compare option allows a user to transition between before and after images. The split image option allows a user view before and after images side by side. The inverse option creates the mirror image of all or only a portion of an image that has been designated by the user. The blend tool will blend edits with the surrounding area. Many of the options shown are also implemented as separate tools under *View* in the main menu. These are described in greater detail below.

It is noted that the side bar menus available for the drawing tools are similar to the shape tool side bar menus shown. They do, however, typically include an option wherein the user may choose the intensity or opacity of a color used in conjunction with a draw tool.

With reference again to FIGURE 10, a test is made at block 244 to determine if the pen tip has been pressed at a location outside of the autoblend box. If the pen tip was pressed at a location outside the autoblend box, the edit area is pasted with a blending of the edges at block 260. Otherwise, a test is made at block 262 to determine if the tip location was within the approximate three-, six-, nine-, and twelve-o'clock areas of the autoblend box. A pressing of the tip within any of these areas results in the edited area being pasted without blending, as indicated at block 264. As indicated at block 266, a selection in a location in the autoblend box apart from the three-, six-, nine-, and twelve-o'clock areas will allow the image to be moved. In this case, the edited area will track movement of the pen as long as the tip remains pressed. After a move is completed, the routine loops to block 242.

If a paste has been accomplished using blocks 260 or 264, a test is made at block 268 to determine if the user wishes to exit the shape routine, e.g., by pressing the side button. If not, the routine loops to block 232 where a new area of the image may be considered. Otherwise, the routine returns to block 82 of FIGURE 3.

FIGURES 12A and 12B illustrate two exemplary shape tools that are available when using the aesthetic imaging system. With reference to FIGURE 12A, a cutout tool is unique in that a user can select an area of the image to be cut out, thereby creating a "hole" in the image, and an identical image underneath the cutout image can then be moved in all directions as it is viewed through the hole. The cutout feature is especially useful for profile views including chin augmentation, brow lifts, and maxillary and mandibular movement; and frontal views, including otoplasty, brow lift, lip augmentation, nasal base narrowing, and maxillary and mandibular movement.

At block 270, the current image is copied to a working buffer. As is discussed in FIGURE 10, when the cutout subroutine is called the user has defined an area of the image to be edited. At block 272, a boundary is created around the designated area designated in block 234 of FIGURE 10. At block 274, the working area is displayed inside the boundary, and the current image displayed outside the boundary. In this manner, the image in the working buffer can be moved relative to the image in the current buffer until the desired alignment has been achieved. The program then returns to the routine of FIGURE 10.

Upon returning to block 238, the edit may be frozen by selecting with the pen. Thereafter, the autoblend box is displayed. Selecting within the area 252 of the autoblend box allows the designated area to be moved. Selecting anywhere outside the autoblend box will make the edit permanent, with automatic blending. Selecting

dotted line 386. Once the area has been selected, a user may tip the pen to designate a stretch point within the selected area. As shown in FIGURE 18A, a stretch point 388 has been designated near the top portion of the patient's right upper lip. Once the stretch point has been designated, the user may float the pen in the desired direction that they would like to stretch the image. The portion of the image that is located at the stretch point is pulled in the direction that the user floats the pen, with the area surrounding the stretch point either expanded or compressed. That is, the area in the direction that the user floats the pen is compressed, and the area away from the direction that the user floats the pen is expanded. The amount of expansion or compression is dictated by the distance of the area away from the stretch point, in a manner discussed in greater detail below. Preferably, the image is manipulated in real time, so that the user is presented with a seamless and continuous stretching or movement of the selected feature.

The technique used to implement the warp tool is portrayed in FIGURES 19A-19E. A user first defines a manipulation area 420 to be edited by circling the desired feature of the patient. As shown in enlarged detail in FIGURE 19B, when the manipulation area has been selected, the aesthetic imaging system creates a pixel map of a warping area 422 that completely encompasses the manipulation area. For computational purposes, the warping area is preferably rectangular and approximately 33% larger in area that the manipulation area. It will be appreciated, however, that the warping area may be differently shaped or sized depending on the particular application and available system hardware.

After defining the manipulation area, the user selects a stretch point 424 within the manipulation area by tipping the pen at a desired location within the area. As shown in FIGURE 19C, when the stretch point is selected, the aesthetic imaging system maps four rectangles 426a, 426b, 426c, and 426d in the warping area. One corner of each rectangle is defined by the stretch point, and the diagonally opposing corner is defined by a corner of the warping area. Perpendicular lines 427 drawn through the stretch point intersect the warping area boundary at points 428a, 428b, 428c, and 428d. After the stretch point is selected, the user may float their pen to manipulate the selected feature, for example in the general direction indicated by arrow 430.

As the user floats the pen to warp the selected feature, the rectangles in the warping area are distorted. In FIGURE 19D, the stretch point has been moved upwards and to the left in the warping area, to an intermediate location 432.

example, a stretch point 392 may be positioned on the upper portion of the left lip, and the pen floated in a direction generally designated by the arrow 394. As shown in FIGURE 18C, this generally causes the upper left portion of the lip to be made fuller to match the upper right portion of the lip. Again, during the warping the aesthetic imaging system automatically expands or contracts the surrounding unmanipulated area to ensure that there are no discontinuities between the upper left and the unedited portion of the face.

The warp tool with multiple stretch points is a very powerful tool as it allows the user to quickly manipulate an image with a minimum use of drawing tools or piecemeal editing. Because the warp tool performs the manipulation in real-time, the edits are accomplished very quickly and fluidly. A user may therefore generate a desired image in a minimal amount of time.

While the warp tool described above requires the user to define the manipulation area 420 to be edited prior to the creation of a warping area by the imaging system, it will be appreciated that the warping area can alternatively be automatically defined by the aesthetic imaging system. In such an alternative system, rather than defining a manipulation area by circling a region of the image, the user simply selects a stretch point 424 and floats the pen in the desired warping direction. The imaging system automatically defines a rectangular warping area 422 of a predetermined size that surrounds the stretch point. As the user moves the stretch point, the area within the warping area is warped. Moreover, the size of the warping area 422 may also be dynamically adjusted by the imaging system. The farther the user floats the pen in a desired warping direction, the greater the imaging system sizes the warping area 422. A greater area of the patient's image will therefore be subject to the warping as the stretch point is pulled a farther distance. Automatically defining and dynamically adjusting the warping area allows the user to quickly and easily warp an image.

V. Viewing an Image

FIGURE 13 illustrates an exemplary routine for implementing the view features of the imaging program. In FIGURE 13, the solid blocks indicate user interface options presented to the user by the aesthetic imaging system and the dashed blocks represent system responses to the decisions made. The view group includes: Compare, Prioritize, Split Image, Mirror Image, and Restore to Original, as well as other options including Zoom and Emboss. At block 300, a test is made to determine if the *Compare* option has been selected.

With reference again to FIGURE 13, if the Compare option has been selected, a test is made at block 309 to determine if the entire image is to be compared or only certain portions of the image, i.e., using the Prioritize option. If less than the entire image is to be compared, the user is prompted to enter the area or areas that are to be compared at block 310. A user may then define one or more "priority areas" by freehand circling the desired area. When the priority areas or defined, or if all of the edits are to be reviewed during the comparison, at block 311 the user is prompted to float the pen in a vertical motion on top of the tablet to transition between the original and modified images, in accordance with the Compare feature discussed above. An illustration will clarify this point.

In FIGURE 14B, a first priority area 312 has been defined that corresponds generally to the nose. Given this selection, the nose area only will transition from original to modified as the pen is moved, with the rest of the image being displayed unedited. Thus, the modifications to the chin and neck no longer are shown. In FIGURE 14C, a second priority area 314 has been defined that corresponds generally to the chin. The first priority area 312 has been kept. Given these selections, the nose and chin areas only will transition from original to modified as the pen is moved, with the rest of the image being displayed unedited. Thus, the modifications to the neck are not illustrated.

With reference to FIGURE 14D, a third priority area 316 has been defined that corresponds generally to the neck, along with the former designations. Given these selections, all three priority areas 312, 314, and 316 transition with movement of the pen. Again, the undesignated portions of the image are displayed in an unedited form, even if parts of the image outside the priority areas have been edited (no edits are shown). Because edits have not been made, from a user's standpoint the transition in FIGURE 14D appears to be a comparison between the original and modified images.

While preferably the user defines the priority areas on the image being edited, it will be appreciated that the priority areas may also be automatically defined by the aesthetic imaging system. A comparison may be made between an original image stored in a buffer and the edited image that has been modified by the user. Any areas containing differences between the original and the edited image may be highlighted by the aesthetic imaging system, and a priority area automatically defined for each area containing differences. Whether a priority area is defined may also depend on the number of differences between the original image and the edited image.

from zero to 100 percent transition (zero percent being the original image and 100 percent being the edited image), by floating the pen up or down above the tablet to establish the view, and the pressing the tip of the pen against the tablet to freeze the transitional image, as indicated in block 322. If the tip is pressed again, the frozen image is saved. The save options are available with or without the priority areas in effect. After the save has been accomplished, or if the user did not wish to save a transitional view of an image, the Compare option is complete and the routine branches to block 326.

In an alternative embodiment of the invention, the Compare option allows a user to compare a modified image with any edits made to the modified image during the current editing session, i.e., before the changes are permanently saved to the modified image. Specifically, with reference to FIGURE 2, this embodiment of the Compare option contrasts the image in the current image buffer 54 with the image in the modified image buffer 52. As discussed above, this embodiment of the Compare option may also be used in conjunction with the Prioritize option to allow the user to select priority areas for comparison. In this case, the priority areas transition from the modified to the current image, while the modified image only is displayed in the other (nonselected areas) areas.

At block 326, a test is made to determine whether the user wishes to view a split image. The *Split Image* option is used on a frontal picture only, and allows a patient to see his or her asymmetries. If a split image view is desired, the user is prompted to select an image, e.g., original or modified, at block 330. At block 332, a vertical centerline is displayed on top of the selected image. The user is then prompted to position the centerline at the location desired, as indicated at block 334. Typically, the centerline will be positioned to dissect the image into equal halves, using the nose and the eyes as reference points. At block 336, the aesthetic imaging system displays two images, one showing the left halves pieced together and the other the right halves pieced together. Specifically, the aesthetic imaging system will produce an inverse image of the left (right) half and then add it to the left (right) half.

FIGURES 15A-15C illustrate the resultant images that are displayed when the Split Image option is invoked. In FIGURE 15A, a frontal image 350 of a patient is shown, including a centerline 352 that has been positioned at the center of the patient by a user. FIGURE 15B is an illustration of the left halves of the image after being pieced together by the aesthetic imaging system, as indicated by reference numeral 354. FIGURE 15C is an illustration of the right halves of the image, as

To further reduce the distraction caused by the menu bar, preferably the menu bar 412 may be moved by a user to different locations on the screen 414. For example, the menu bar may be moved by a user to the bottom of the screen. Particularly when editing the face of a patient on the screen, the majority of the editing will take place on the upper two-thirds of the screen. Locating the menu bar on the bottom of the screen therefore positions the menu bar away from the area on which the patient should remain focused. It will be appreciated that techniques for moving a menu bar to various locations on a screen are known to those skilled in the art of designing user interfaces.

FIGURE 21 is a flow chart of an exemplary routine for implementing a zoom feature in the aesthetic imaging program. The zoom feature allows a user to increase the scale of the image to better view a selected area and to improve the ability of the user to edit fine details in the image. At a block 400, a zoom point is selected by a user. The zoom point identifies the center of the image to be expanded under the control of the user. At a block 402, the picture is adjusted to position the zoom point at the center of the monitor. Centering the picture ensures that as the image is enlarged, the portion of the image surrounding the zoom point will be displayed. At a block 404, the user is allowed to input a desired magnification factor. Preferably, the magnification factor is selected by floating the pen from the bottom (minimum magnification) to the top (maximum magnification) of the tablet. As the user floats the pen over the tablet, the image on the monitor is correspondingly magnified and redisplayed at a block 406. With each redisplay of the image, at a block 408 a test is made to see if the user has frozen the image by pressing or tipping the pen. Once the image is frozen at a desired magnification, a user can manipulate the image using the array of drawing tools described above. It will be appreciated that for very fine work, such as removing small wrinkles surrounding a patient's eyes, the ability to magnify the image increases the quality of the editing that may be achieved.

Several refinements of the zoom feature may be incorporated in the aesthetic imaging program to improve the results of the zoom. For example, a smoothing function may be incorporated in the zoom feature to ensure that as the image is magnified it does not become "pixelly" or grainy. The smoothing function may be implemented in software. Preferably, however, the smoothing function is implemented in hardware, such as a smoothing feature provided in the Targa 2000 board described above and incorporated in the aesthetic imaging system. Further, feedback may be provided to the user in the form of a numerical display on the image

VI. Post Editing Image Manipulation

The aesthetic imaging system 20 contains several modules to allow an image to be manipulated to improve the quality of the image, to analyze the image, or to prepare the image for meetings or presentations. FIGURES 22A-22D illustrate an exemplary routine for implementing some of the modules in the aesthetic imaging system. The modules are accessible from a pull-down menu or other function key.

The first module that the user may select is a *color correction* module 500 that allows the user to adjust the color of an image so that the image matches the color of a target image. If the user has selected the color correction module, at a block 502 the user is allowed to select an original image and a target image. FIGURE 23 depicts a preferred screen of the aesthetic imaging system when the color of an image is to be corrected. On the left hand side of the screen, a number of stored images 620a, 620b, 620c, 620d, and 620e are displayed in an image index 620. From the image index, the user may select an original image to be manipulated and a target image from which the color is to be copied. The user selects the original and target images by moving the cursor over the desired image, selecting the image by tipping the pen on the tablet, and dragging the image to the appropriate location on the screen. The original image is selected by dragging an image from the image index 620 to an original image box 622, while the target image is selected by dragging an image to a target image box 624. When selected, each of the images is displayed in the appropriate box by the aesthetic imaging system.

Returning to FIGURE 22A, at a block 504 the user is allowed to select comparison points on the original image and the target image. An original comparison point 626 is selected on the original image by moving the cursor to the appropriate point on the original image and tipping the pen on the tablet. Similarly, a target comparison point 628 is selected on the target image by appropriately moving the cursor and tipping the pen on the tablet. As discussed below, the comparison points define the color correction that is made to the original image.

The image captured by the image capture board in the aesthetic imaging system is comprised of a number of pixels, each pixel having an 8-bit red component, an 8-bit green component, and an 8-bit blue component. At a block 506, a comparison is made of the red, green, and blue (RGB) components of the pixels in the regions immediately surrounding the selected comparison points. That is, the RGB components of the pixels in the region immediately surrounding the original comparison point are compared with the RGB components of the pixels in the region

color composition, and modify an original image to match the target image so that an accurate comparison may be made between the images.

At a decision block 514, the user may continue to adjust the color of the image if the desired color is not achieved. At a block 504, the user may move the original comparison point 626 or the target comparison point 628 to change the image depicted in the adjusted image box 630. Such modifications occur in real time, allowing the user to quickly try a variety of different color corrections. If the desired color of the image is achieved, at a block 516 the adjusted image contained in the adjusted image box 630 is stored. It will be appreciated that the adjusted image may be stored over the old original image, or stored at a new memory location to preserve both the original image and the adjusted image. Once an offset is calculated, the user may also continue to modify a number of images using the same offset. To continue to modify images, the user selects another image from the image index 620 and drags the image to the original image box 622. The selected original image is automatically modified using the current offset, and displayed in the adjusted image box 630. The adjusted image is then stored. In this manner, a user can quickly adjust the color of a number of images so that the images may be accurately compared.

Returning to FIGURE 22A, the second module that the user may select is an *orientation correction* module 520 to allow the size and orientation of an image to be corrected. If the user has selected the orientation correction module, at a block 522 the user is allowed to select an original image and a target image from an image index. As depicted in FIGURE 24, an original image is selected from the image index 620 and displayed in an original image box 640. A target image is selected and displayed in a target image box 642. Oftentimes, the orientation or size of the patient's image in the original image will be different from the target image. For example, in the representative images shown in FIGURE 24, the patient's head in the original image is tilted slightly from the orientation in the target image. To correct for the patient tilt in the original image, at a block 524 the user selects at least three reference points 644 on the target image. At a block 526, the user selects at least three corresponding reference points 648 on the original image. The reference points selected on the original image should be located at approximately the same location on the patient's image as they are located on the target image.

At a block 528, a calculation is made to determine the transform necessary to rotate and size the original image so that it will be the same size and orientation as the target image. Those skilled in the art will appreciate that the relative size of the

underlying image. While each measurement option will be discussed as being implemented on a separate image below, it will be appreciated that the various different measurements may be combined on a single image.

At a decision block 542, a test is made to determine if the user has selected the *angle measurement* option from the measurement module. FIGURE 25A depicts the screen of the aesthetic imaging system when the user selects the angle measurement option. At a block 544, the user initially selects an origin 650 for the angle measurement by moving a cursor 656 to the appropriate location on the screen and tipping the pen on the tablet. To make an angle measurement, at blocks 546 and 548 the user must define a first line 658 and a second line 660 that intersect at the origin. To define the first line, a dashed line 652 is displayed that passes through the origin after the origin has been selected. A solid line segment 654 extends from the origin along the dashed line to a point where the cursor 656 is located. Movement of the cursor 656 along the dashed line 652 causes the length of the solid line segment 654 to change. Movement of the cursor around the origin 650 causes the angle of the dashed line with respect to the origin to change. When a desired location of the dashed line is achieved, such as parallel with a patient's feature, the user tips the pen to set the location and length of the first line 658. After the first line is defined, the dashed line 652 extending through the origin is again displayed to allow the user to define the second line. Movement of the cursor changes the direction and length of the line segment along the dashed line. As depicted in FIGURE 25A, the second line 660 is defined so that it forms an angle 662 with respect to the first line 658. The user selects the orientation and length of the second line by tipping the pen when the cursor is at the desired location.

After the user has defined the two lines on the patient's image, at a block 550 the angle between the two lines is calculated and displayed on the image. Two lines that intersect at the origin 650 will define two angles, one greater than or equal to 180 degrees, and one less than or equal to 180 degrees. Preferably, the aesthetic imaging system automatically displays the calculated angle that is less than or equal to 180 degrees. The angle is displayed at a location 664 that is opposite the defined angle. While preferably the angle is displayed in degrees, it will be appreciated that the angle may also be displayed in other units of measure, such as radians.

In addition to displaying a single angle, the aesthetic imaging system also allows the user to link multiple angles together. For example, as shown in FIGURE 25A, three angles are defined by a common line 666. To allow the user to

by the user is calculated by known methods and displayed at a location 690 adjacent the defined area. Those skilled in the art will appreciate that the calculation of the area 690 is a simple matter once the image has been calibrated. The area may be expressed in English units, metric units, or any other units of measure used to calibrate the image. Further, the user may define any area within the image to be measured.

Similar to making an area measurement, the user may also make a distance measurement on the image. At a decision block 568, a test is made to determine if the user has selected the *distance measurement* option. FIGURE 25C depicts an image in which a user has made several distance measurements. If the user has not calibrated the image, at a block 570 the image must first be calibrated in the manner described above. If the image is already calibrated, at a block 572 the user defines a line segment by selecting a first end point 700 and a second end point 702. After selecting the two end points, a line 704 is displayed on the image connecting the two end points. At a block 574, the two-dimensional distance between the two points is calculated and displayed at a location 706 adjacent the line. Those skilled in the art will appreciate that calculating a two-dimensional distance on the image is straightforward once the image has been calibrated. The distance may be displayed in English units, metric units, or other standard units of measure.

As with the angle measurements, the aesthetic imaging system also allows a user to chain multiple distance measurements together. If the user has selected the chaining option at a decision block 576, the user is allowed to enter another end point after the first two end points are displayed at a block 578. The third and subsequent end points are connected to the preceding end point by a line, and the distance of each line displayed. As depicted in FIGURE 25C, the user may use the chaining option to quickly enter a number of lines 708 to measure around a desired area or between multiple points.

With reference to FIGURE 22C, the fourth measurement that a user may make on an image is a proportion measurement. At a decision block 580, a test is made to determine if the user has selected the *proportion measurement* option. If the user has selected a proportion measurement, the user is presented the option of making a horizontal proportion measurement (comparing the horizontal relationship of features in the image) or a vertical proportion measurement (comparing the vertical relationship of features in the image). At a decision block 582 a test is made to determine if the horizontal or the vertical proportion measurement has been selected.

second end point 732 located at a distance from the eyebrow. After defining the line segment, at a block 604 the user enters a label corresponding to the line segment. As shown in FIGURE 26, a transparent box 734 is displayed to the user at the location where the label will be displayed. The user enters the label using a keyboard or other technique, such as selecting predefined labels from a pull-down menu. The box 734 used to enter the label is preferably transparent to allow the user to see the image of the patient through the box when a label is being entered.

At a decision block 606 the user is allowed to enter multiple labels, each of which are linked to one or more structures on the drawing. For example, a label 736 may be linked to two or more line segments that point to different structures on the image. In FIGURE 26, the label "Lips" is connected by two line segments to each of the patient's lips. The labels are also linked to the line segments so that if the labels are moved, the line segments are correspondingly moved to continue to connect the label with the associated structure. For example, the label "Eye," which points to the eye of the image in FIGURE 26, may be selected by the user and dragged from a first location 738 to a second location 740 as indicated by the directional arrow. Moving the label "Eye" automatically moves the line segment associated with the label so that the label and the structure remain linked.

The aesthetic imaging system modules disclosed above are particularly useful for allowing an imaging professional to manipulate an image to improve the presentation of the image to the patient or to colleagues. Such modules allow a more accurate comparison to be made between two or more images. The result is a more satisfying and beneficial imaging session for a patient.

VII. Treatment Simulations

The aesthetic imaging system of the present invention incorporates a module for simulating the results of laser resurfacing treatment. FIGURE 27A depicts a representative screen of the aesthetic imaging system when the laser resurfacing module has been selected. The laser resurfacing module allows the aesthetic imaging system to display an image of the patient that approximates how the patient will appear immediately following a laser resurfacing treatment and throughout the healing process.

The steps required to simulate the results of the laser resurfacing treatment are depicted in the flow chart of FIGURE 27B. At a block 754, the user initially selects an image to be edited, and defines a region in which the laser resurfacing treatment is to be simulated. The region is defined by the user by circling the desired area. For

As the mask becomes more opaque, more blurring of the image occurs. Preferably, the opacity of the alpha mask 764 is tied to the movement of the cursor to allow the user to change the blurring of the image by floating the pen from the top to the bottom of the tablet.

Because of computational limitations, the blurred image 770 is preferably only calculated once and the amount of blurring varied by changing the opacity of the alpha mask 764 as described above. Alternatively, those skilled in the art will recognize that with additional processing power, the amount of blurring may be varied by directly changing the response of the low pass filter 766. Using the alternative technique, the low pass filter response may be tied to the movement of the cursor so that the user may directly vary the blurriness of the selected region by floating the pen from the top to the bottom of the tablet.

When the user has achieved a desired amount of blurriness to simulate the representative treatment results within the region 752, the user freezes the image of the patient by tipping the pen on the tablet. An image 772 representative of the anticipated treatment results (after the patient has healed) is then stored in a buffer in the aesthetic imaging system.

To simulate the redness and inflammation immediately following the resurfacing treatment, at a block 758 the user selects an amount of redness to be applied to the treated region. The amount of redness may be preset, or selected by the user from a scale of redness. FIGURE 27D diagrammatically represents the process for displaying the selected region 752 in a reddened state. The alpha mask 764 is added to a solid image 774 containing pixels of the desired redness, and the alpha channel values in the resulting mask changed to make the mask semi-transparent. The mask and colored image is then superimposed over the image 772 of the representative treatment results after healing. The result is an image 776 that is representative of the image of the patient after the treatment has been performed, but before the patient has healed.

Returning to FIGURE 27B, the user is allowed to fade the redness of the image at a block 760 to show how the patient will likely look during the healing process. In order to fade the redness of the image, the alpha values in the alpha mask 764 are reduced until the entire mask is transparent. As the mask becomes more transparent, more of the underlying image is visible to the user. Preferably, the transparency of the alpha mask 764 is tied to the movement of the cursor to allow the user to change the redness of the image by floating the pen from the top to the bottom

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In an aesthetic imaging system of the type that manipulates an image of a patient to simulate the effects of a medical procedure, a method for simulating the results of a laser resurfacing treatment, comprising the steps of:

obtaining an original image of the patient;

defining an area in the image in which the laser resurfacing is to be simulated;

creating a mask whereby the areas outside the region in which the laser resurfacing is not to be simulated is transparent and the areas in which the laser resurfacing is to be simulated is opaque;

creating a blurred copy of the original image in the area in which the laser resurfacing is to be simulated; and

adding the mask to the blurred copy of the original image and superimposing the sum of the blurred image with the mask over the original image to simulate the laser resurfacing.

2. The method of Claim 1, further comprising a method for connecting the color of an image comprising the steps of:

selecting one or more comparison points in an original image and a target image;

calculating an average red, green, and blue components of the pixels near the comparison points in the original image and the target image;

determining a difference in the average red, green, and blue components of the pixels near the comparison points in the original and target images; and

adjusting the red, green, and blue components of the pixels near the target points in the original image to equal the red, green, and blue components of the pixels in the target image.

AMENDED CLAIMS

[received by the International Bureau on 30 April 1998 (30.04.98); original claims 1-5 replaced by new claims 1-13 (3 pages)]

1. In an aesthetic imaging system allowing the manipulation of digital images comprised of a plurality of pixels, a method of displaying an edited digital image corresponding to an original digital image wherein the edited digital image differs from the original digital image by at least one edit made to the original digital image, the aesthetic imaging system including a processor, a memory, a monitor, and means for controlling a cursor displayed on the monitor, the method comprising:

defining a plurality of regions in said edited digital image, each of the plurality of regions containing at least one edit that distinguishes each of the plurality of regions from a corresponding region in said original digital image;

allowing a user to select from the plurality of regions a subset of regions; and

displaying a prioritized digital image containing only the edits of the original digital image that are present in the subset of regions.

2. The method of Claim 1 wherein the plurality of regions are defined by encircling the region on the edited digital image with the means for controlling the cursor displayed on the monitor.

3. The method of Claim 1 wherein the plurality of regions are automatically defined by the aesthetic imaging system.

4. The method of Claim 1 further comprising the step of assigning a tag corresponding to each of the plurality of regions.

5. The method of Claim 4 wherein the tag is a textual identifier.

6. The method of Claim 5, wherein the subset of regions are selected from a list of tags corresponding to each region.

7. The method of Claim 1 wherein the original image and the prioritized image are displayed side-by-side.

8. The method of Claim 1 wherein the prioritized image is superimposed over the original image, an opacity of the prioritized image being selectable by a user to allow the user to view a composite image of the prioritized image and the original image, the composite image thereby displaying a variable amount of the edits performed on the original image.

calculating an offset value by subtracting an average of the RGB components of the pixels in a region surrounding the comparison point in the original image from an average of the RGB components of the pixels in a region surrounding the comparison point in the target image,

adding the offset value to the RGB components of each pixel in the original image to correct the color of the original digital image; and

displaying the color corrected original digital image.

13. In an aesthetic imaging system allowing the manipulation of digital images comprised of a plurality of pixels, a method of correcting the size and orientation of an original digital image to substantially match a target digital image comprising:

selecting an original digital image and a target digital image from a memory of the aesthetic imaging systems;

selecting at least three reference points on the original digital image and at least three corresponding reference points on the target digital image;

calculating a degree of rotation and a size adjustment based on the three reference points in the original and target digital images;

rotating the original digital image based on the calculated degree of rotation and scaling the original digital image based on the calculated size adjustment to create a corrected digital image; and

displaying the corrected digital image.

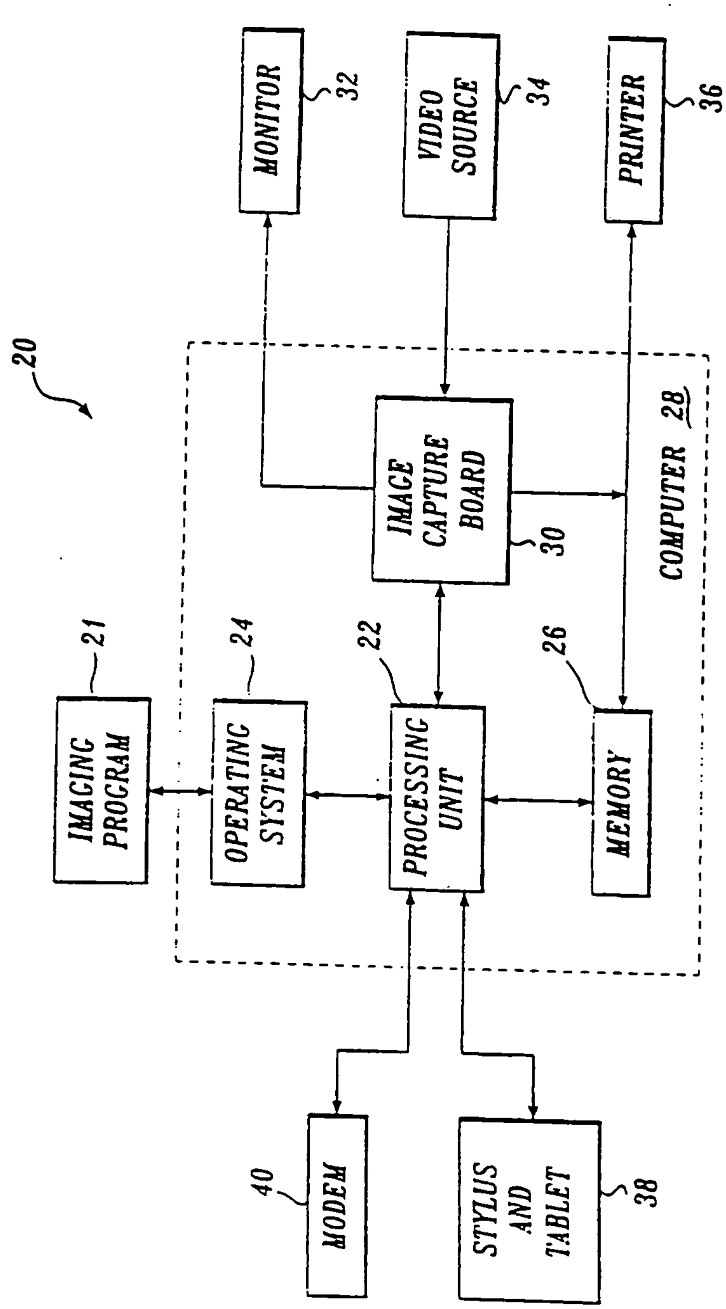

20
IMAGING PROGRAM
21
OPERATING SYSTEM
24
PROCESSING UNIT
22
MEMORY
26
IMAGE CAPTURE BOARD
30
COMPUTER 28
MONITOR
32
VIDEO SOURCE
34
PRINTER
36
MODEM
40
STYLUS AND TABLET
38

Fig. 1.

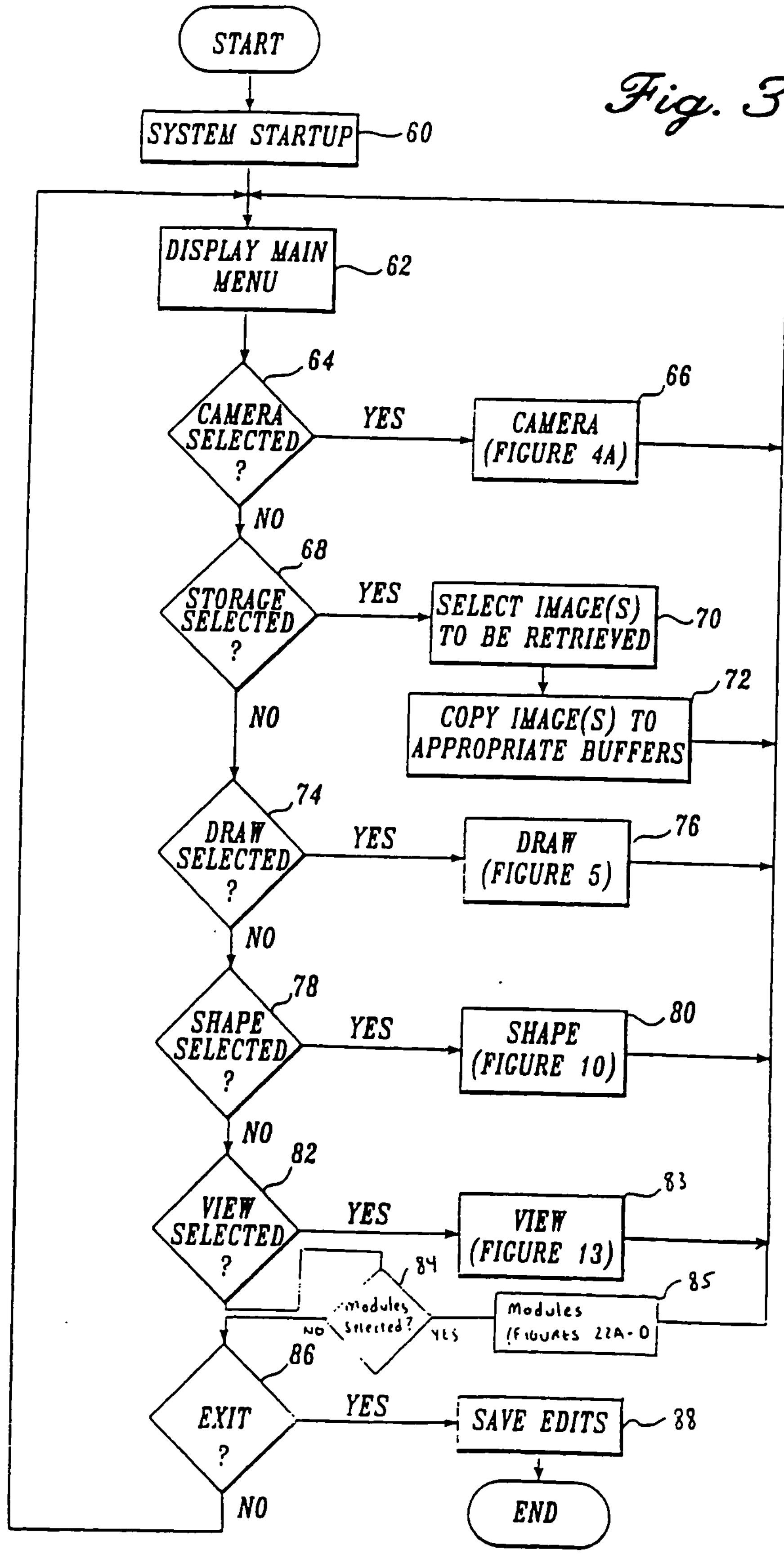

START
SYSTEM STARTUP
60
DISPLAY MAIN MENU
62
CAMERA SELECTED ?
64
YES
NO
CAMERA (FIGURE 4A)
66
STORAGE SELECTED ?
68
SELECT IMAGE(S) TO BE RETRIEVED
70
COPY IMAGE(S) TO APPROPRIATE BUFFERS
72
DRAW SELECTED ?
74
DRAW (FIGURE 5)
76
SHAPE SELECTED ?
78
SHAPE (FIGURE 10)
80
VIEW SELECTED ?
82
VIEW (FIGURE 13)
83
Modules Selected ?
84
Modules (Figures 22A-O
85
EXIT ?
86
SAVE EDITS
88
END

Fig. 3.

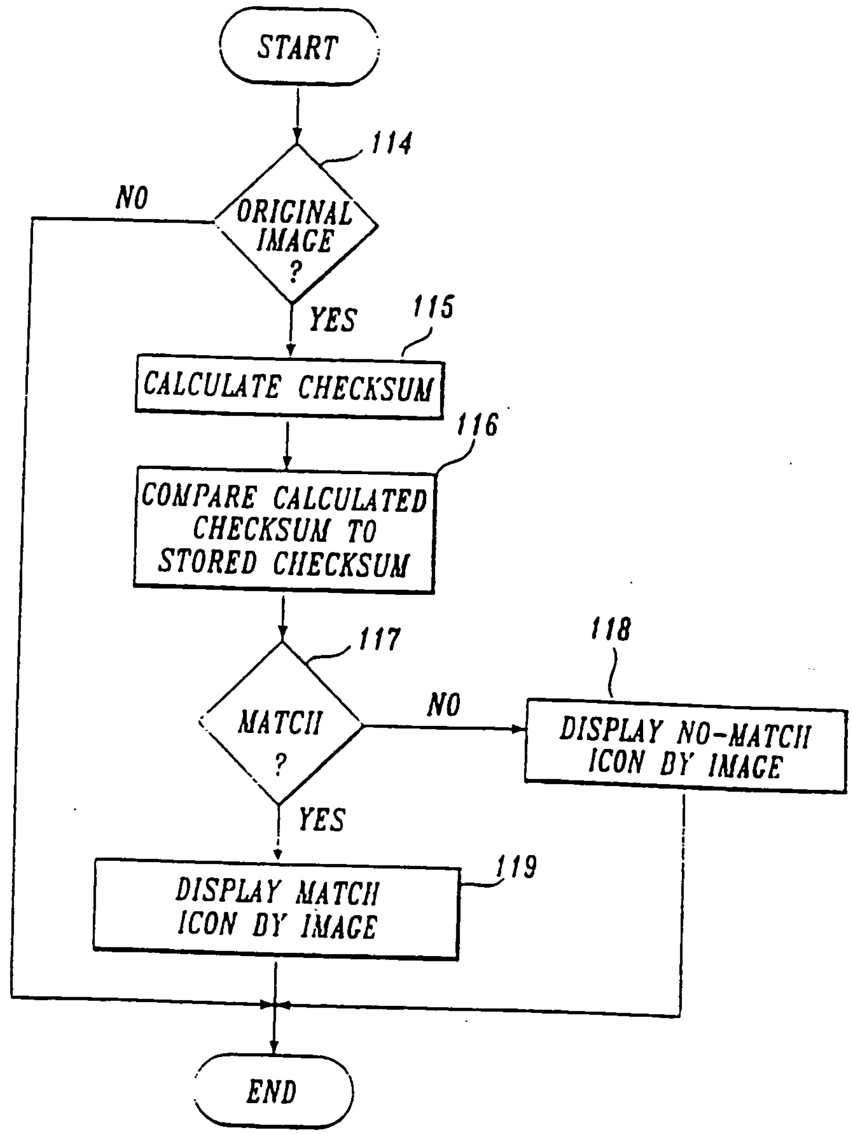

START
114
ORIGINAL IMAGE ?
NO
YES
115
CALCULATE CHECKSUM
116
COMPARE CALCULATED CHECKSUM TO STORED CHECKSUM
117
MATCH ?
NO
118
DISPLAY NO-MATCH ICON BY IMAGE
YES
119
DISPLAY MATCH ICON BY IMAGE
END

Fig. 4B.

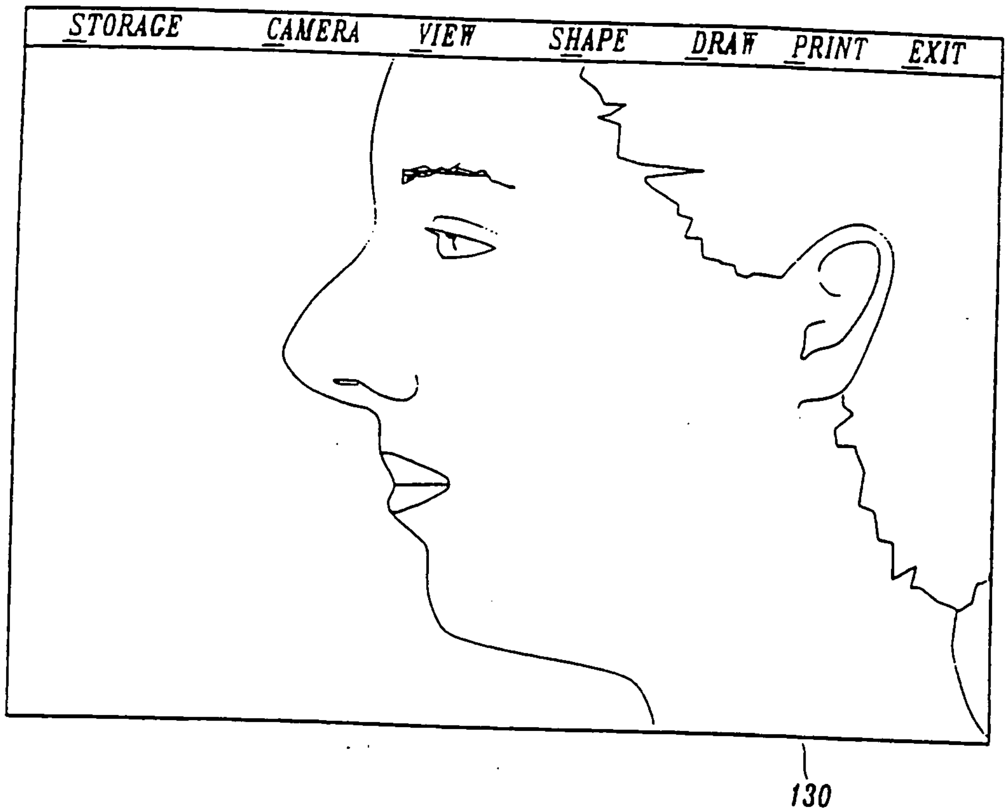
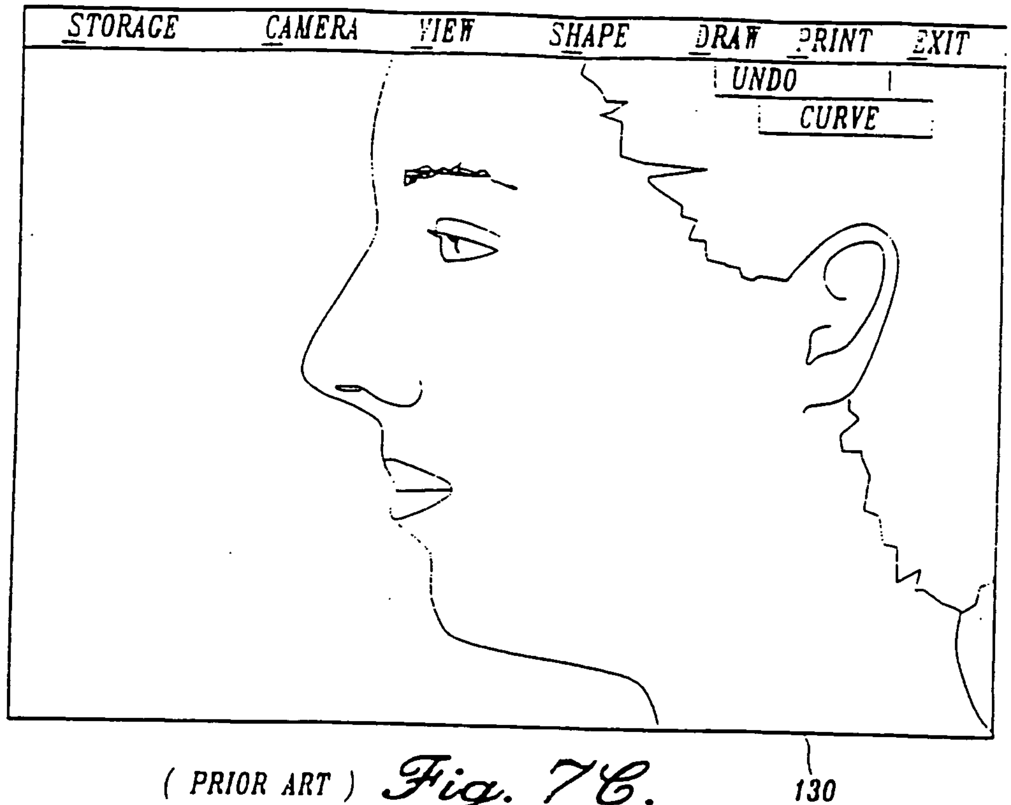
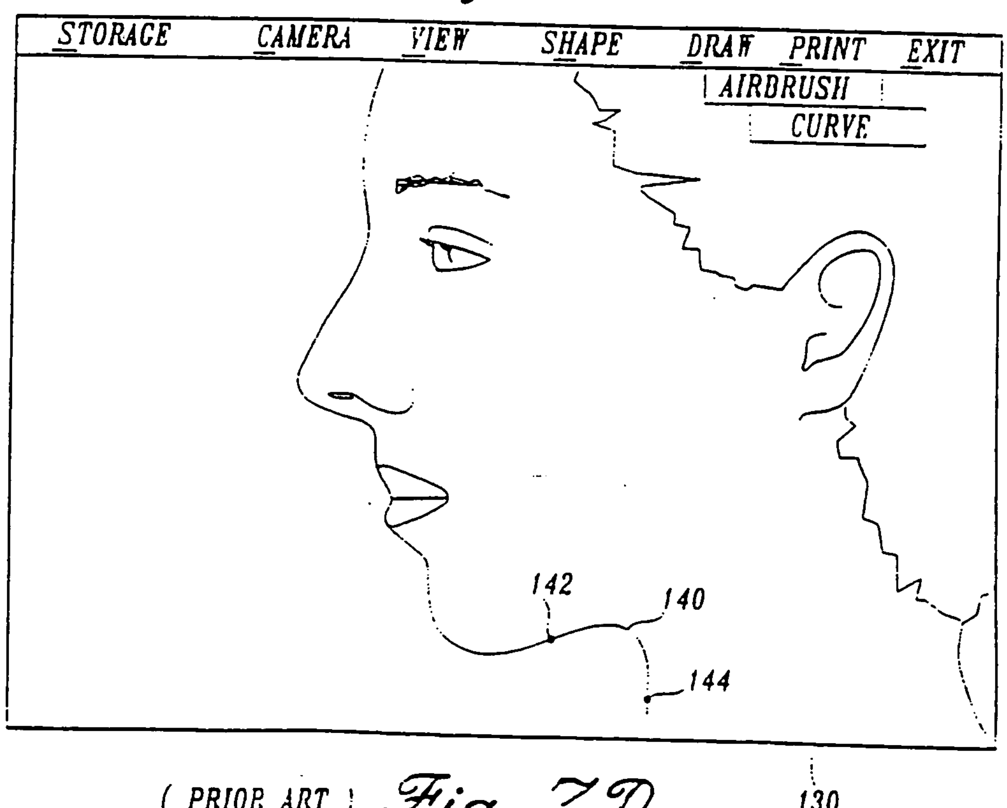


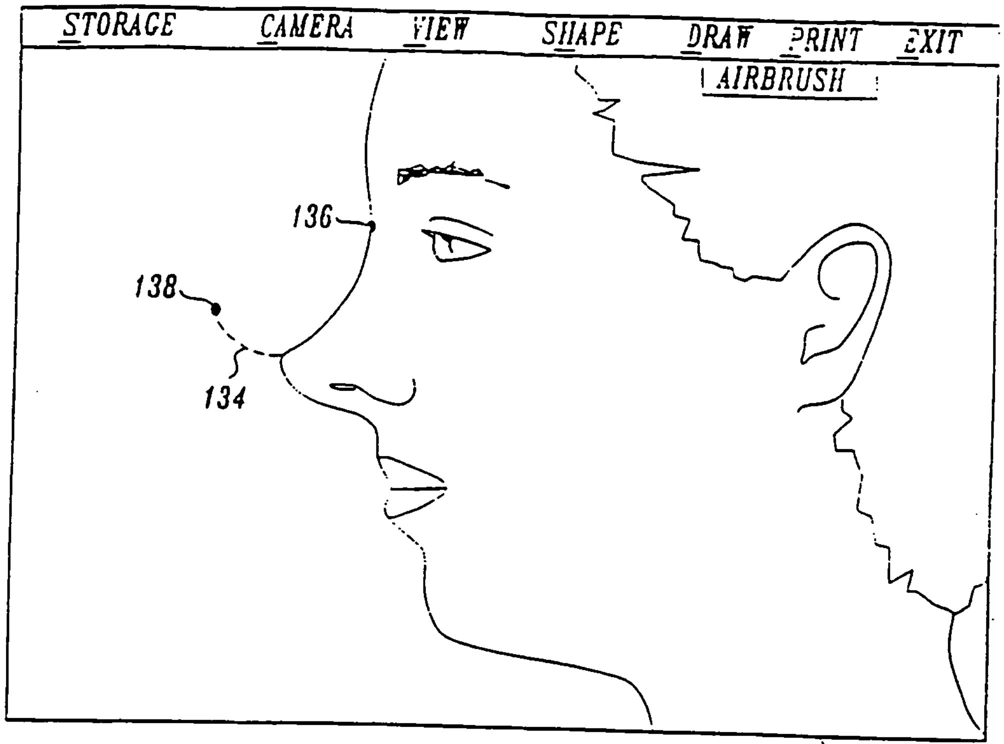
Fig. 6.



(PRIOR ART) Fig. 7C.

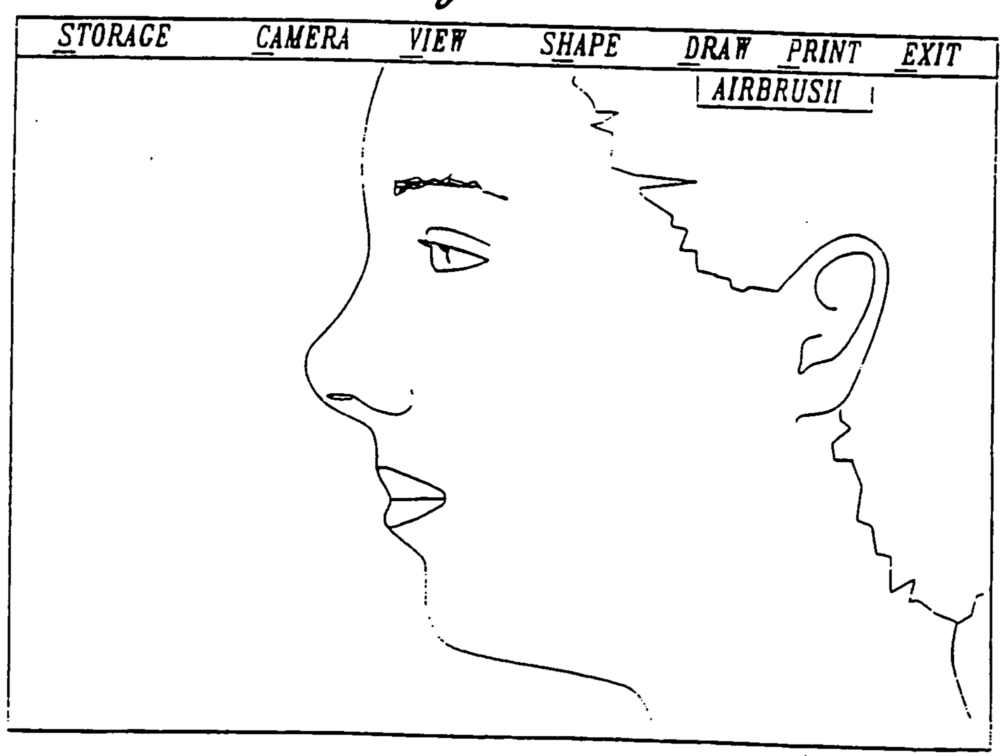


(PRIOR ART) Fig. 7D.



130

Fig. 8A.



130

Fig. 8B.

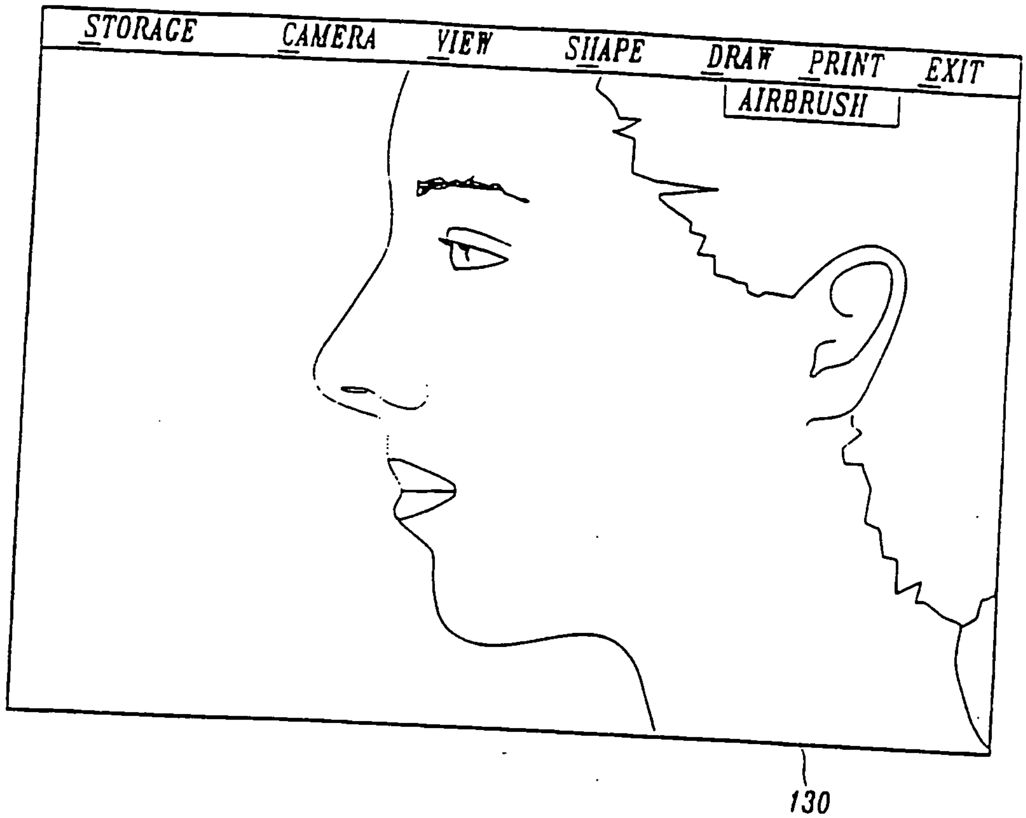


Fig. 8E.

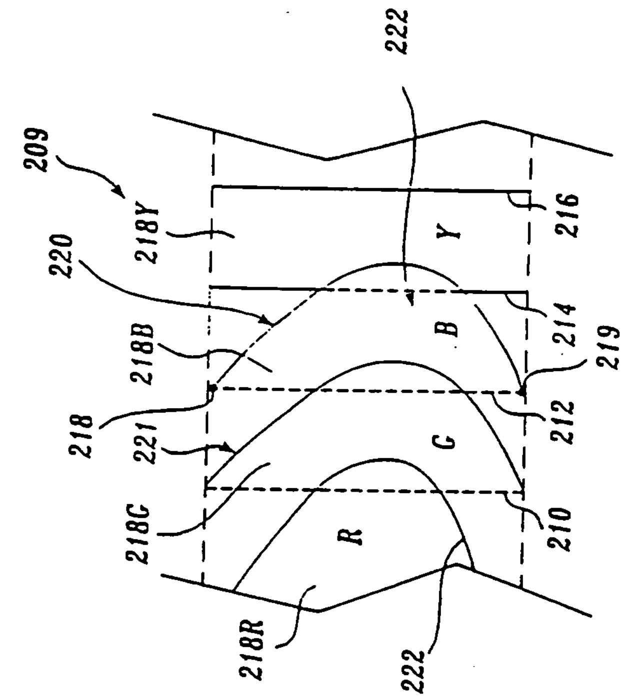

209
218Y
220
218B
218
221
218C
218R
222
Y
B
G
R
216
214
219
212
210
222

Fig. 9C.

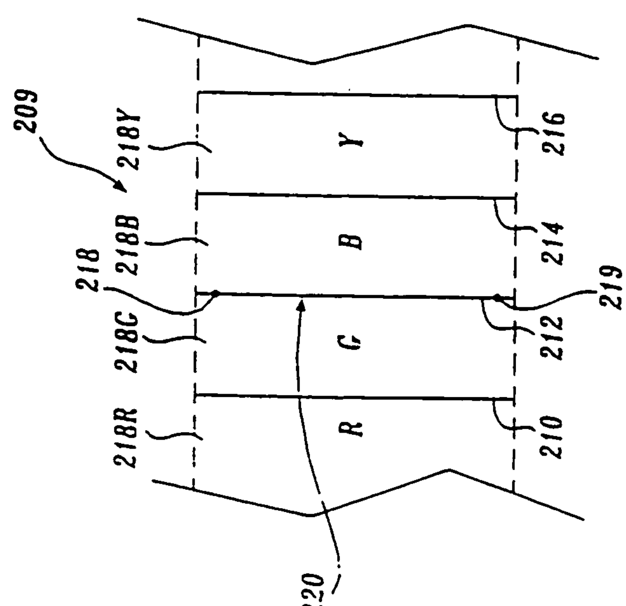

209
218Y
218B
218
218C
218R
Y
B
G
R
216
214
219
212
210
220

Fig. 9B.

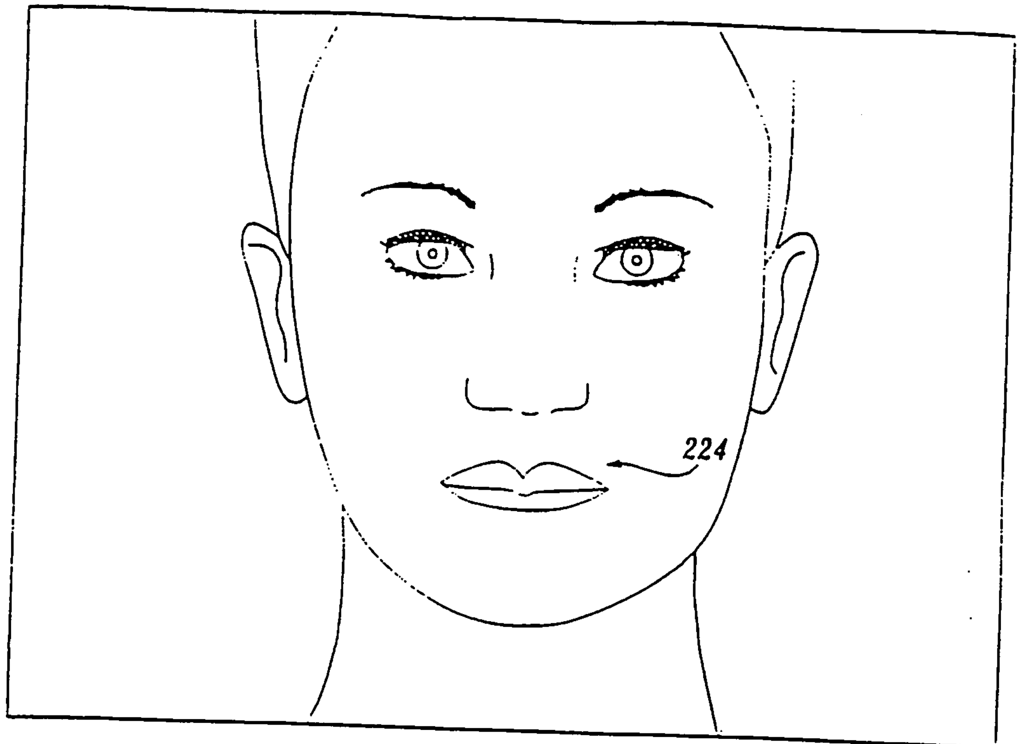


Fig. 9F.

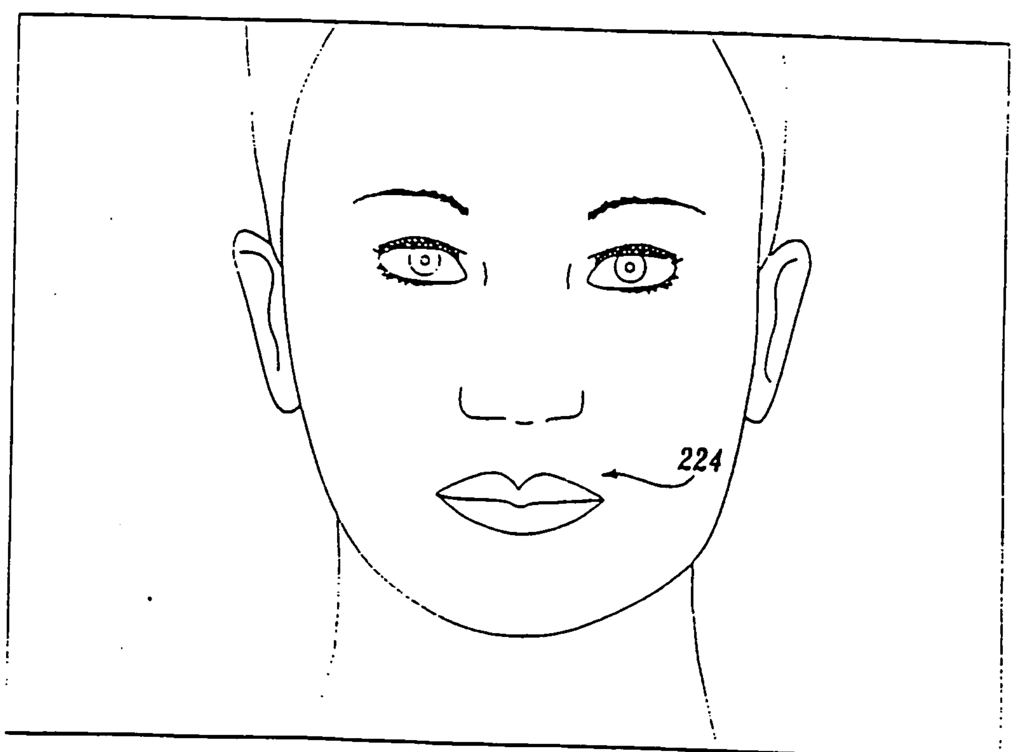


Fig. 9G.

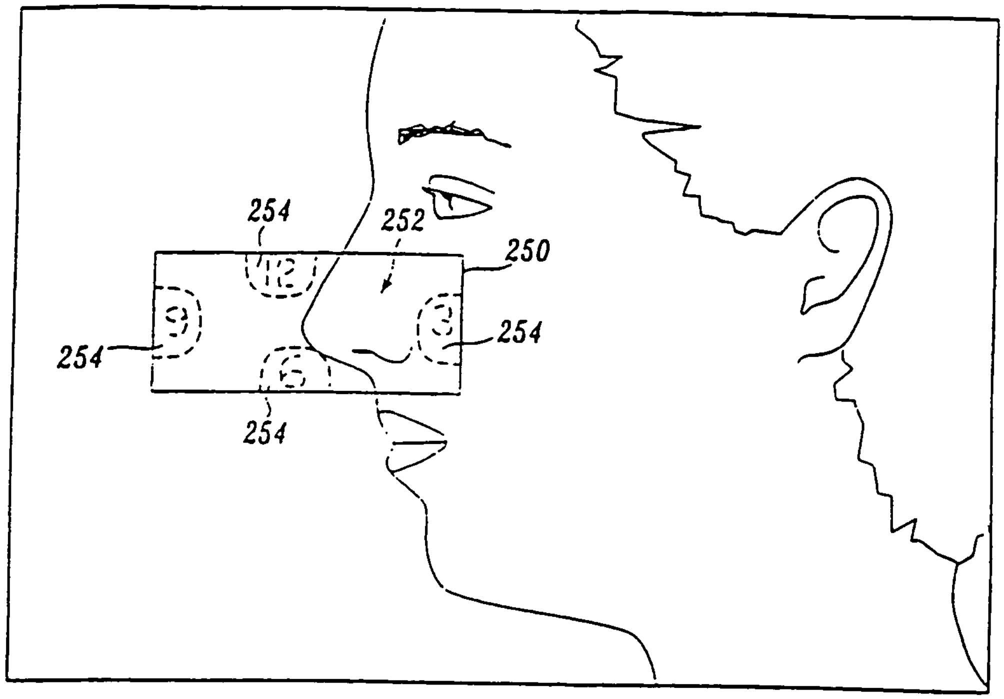


Fig. 11.

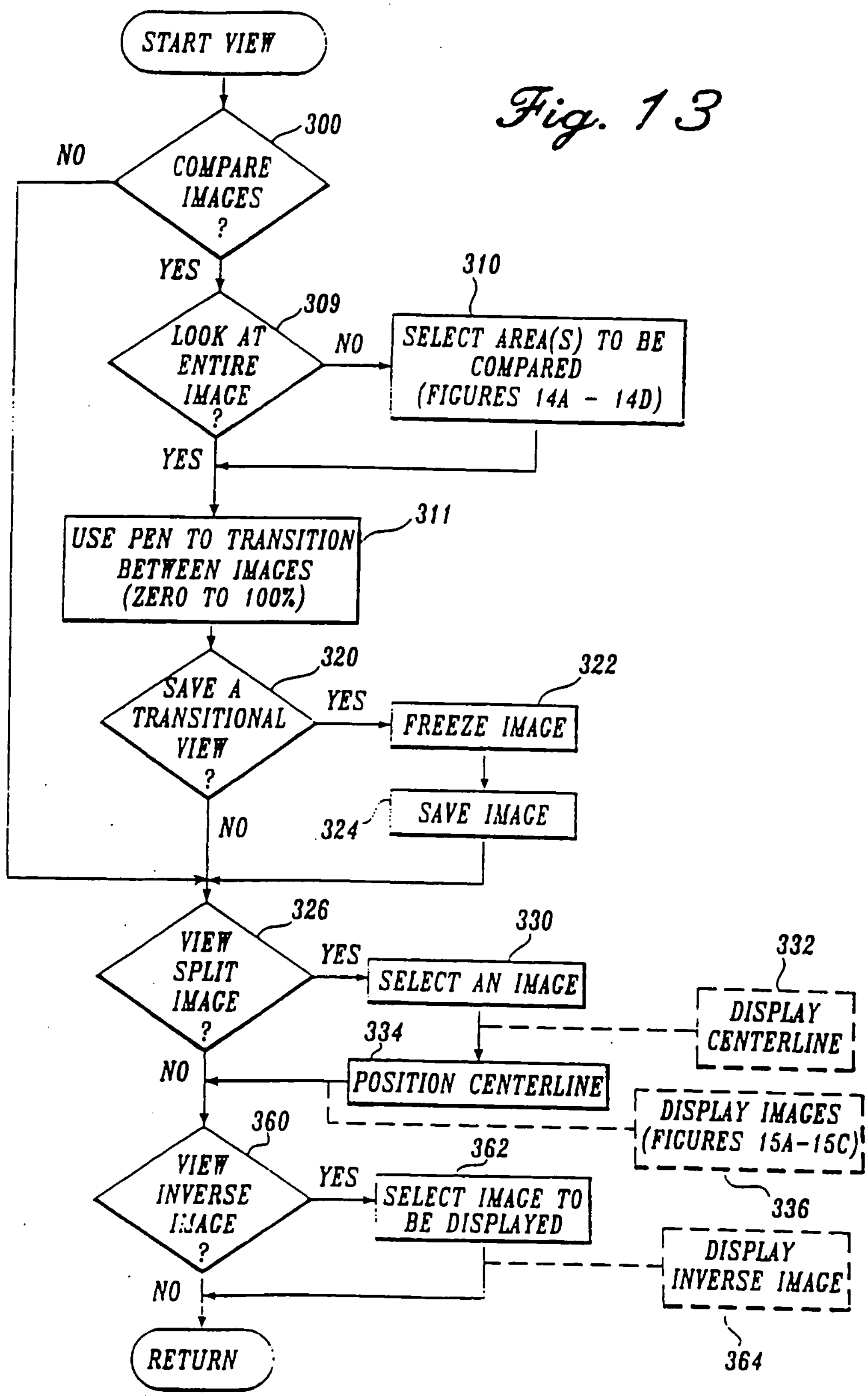

START VIEW
300
COMPARE IMAGES ?
NO
YES
309
LOOK AT ENTIRE IMAGE ?
NO
310
SELECT AREA(S) TO BE COMPARED (FIGURES 14A - 14D)
YES
311
USE PEN TO TRANSITION BETWEEN IMAGES (ZERO TO 100%)
320
SAVE A TRANSITIONAL VIEW ?
YES
322
FREEZE IMAGE
324
SAVE IMAGE
NO
326
VIEW SPLIT IMAGE ?
YES
330
SELECT AN IMAGE
332
DISPLAY CENTERLINE
334
POSITION CENTERLINE
NO
DISPLAY IMAGES (FIGURES 15A-15C)
336
360
VIEW INVERSE IMAGE ?
YES
362
SELECT IMAGE TO BE DISPLAYED
DISPLAY INVERSE IMAGE
364
NO
RETURN

Fig. 13

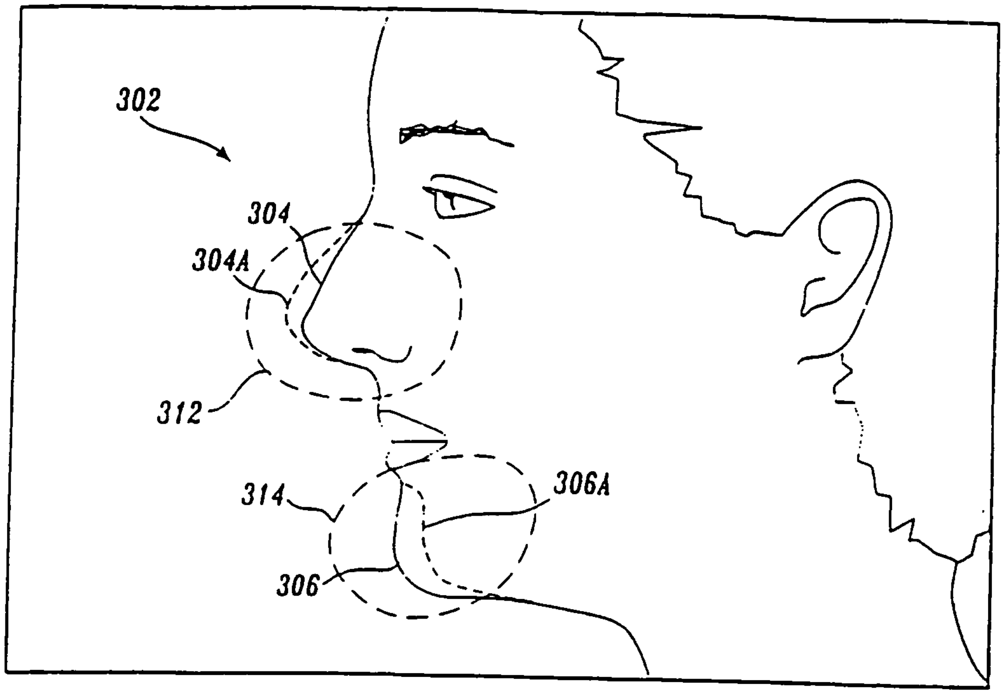


Fig. 14C.

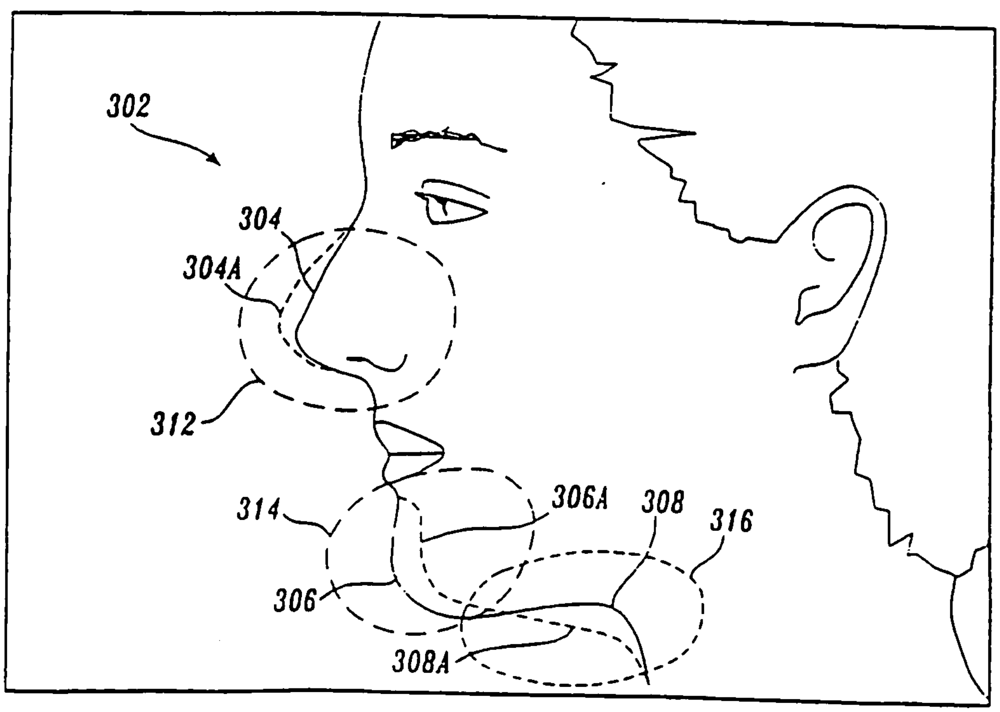


Fig. 14D.

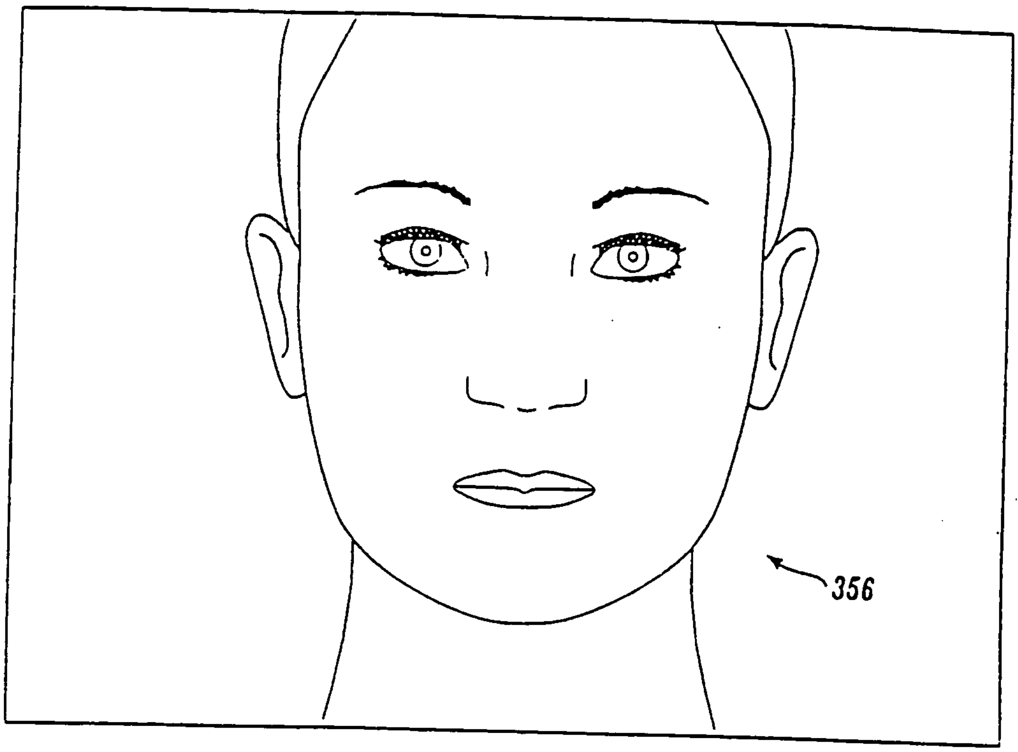


Fig. 15C.

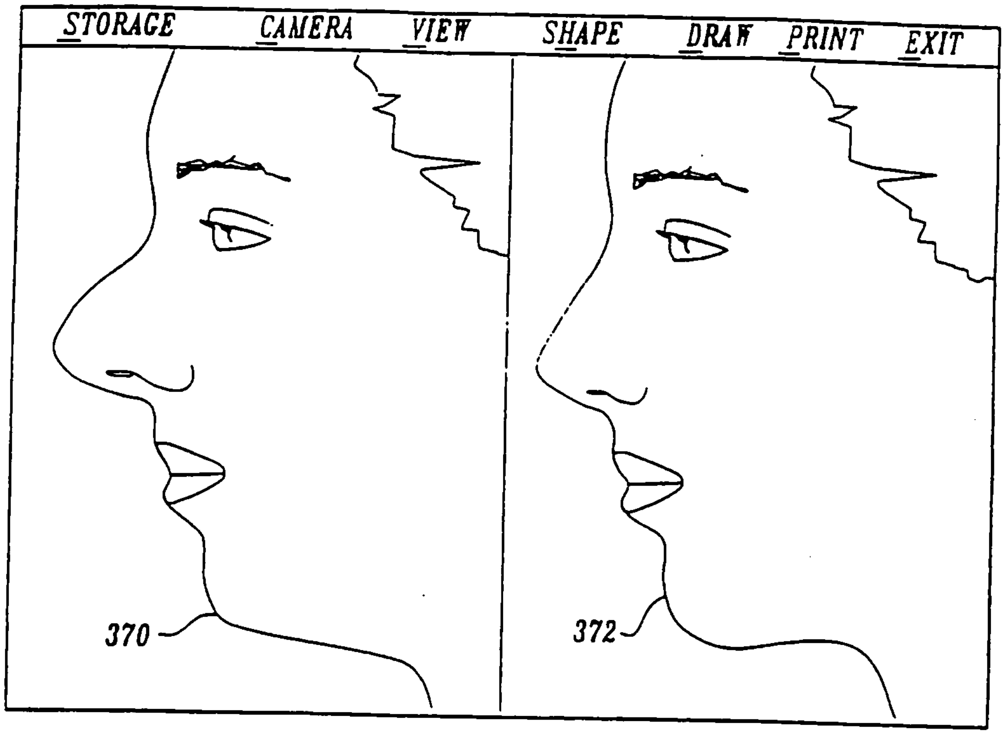


Fig. 17.

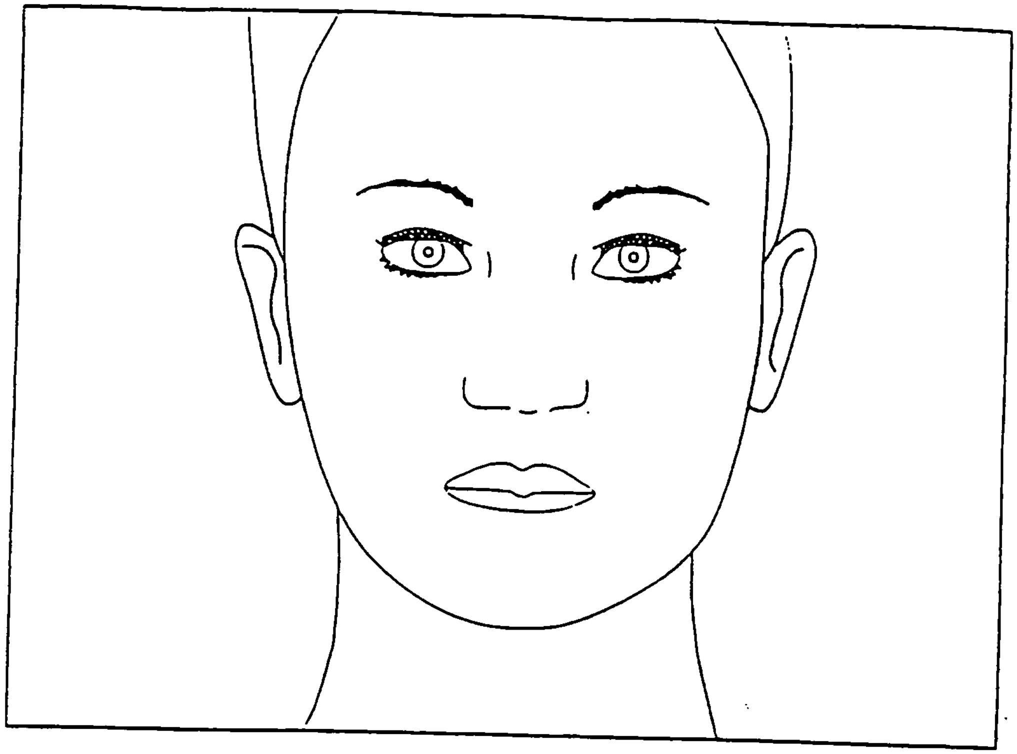


Fig. 18C.

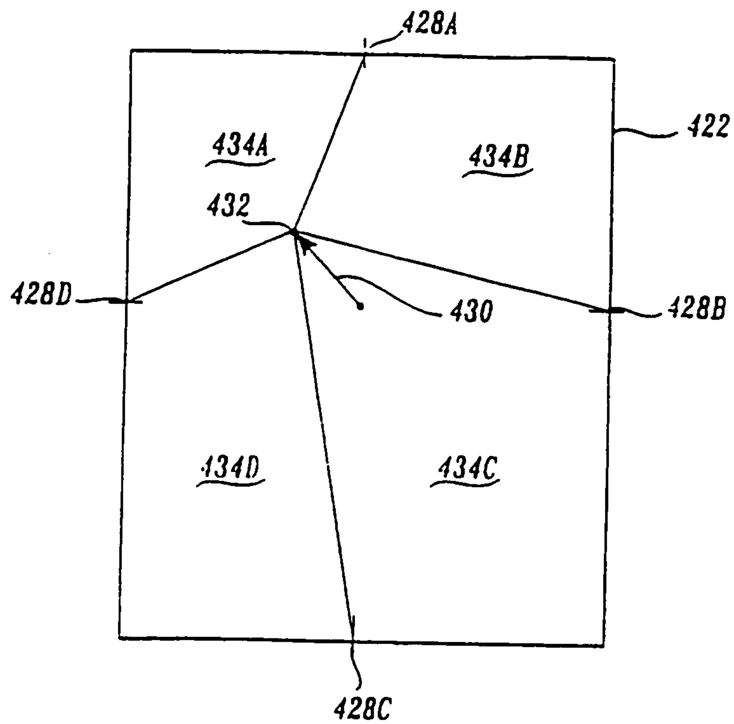


Fig. 19D.

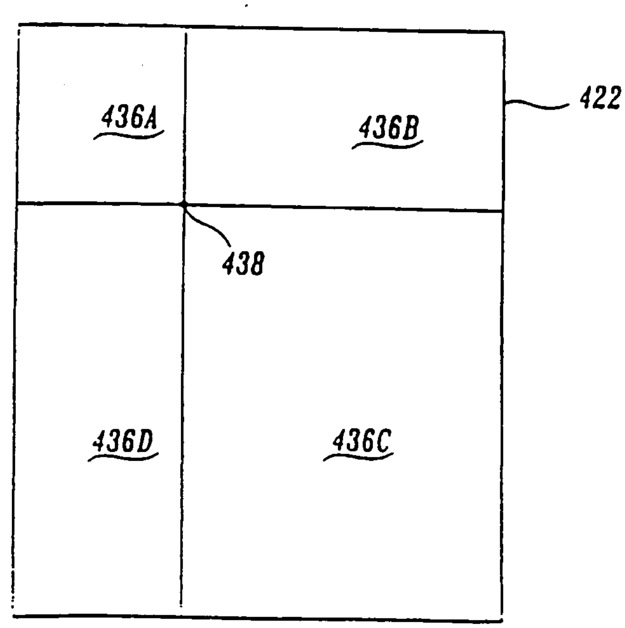


Fig. 19E.

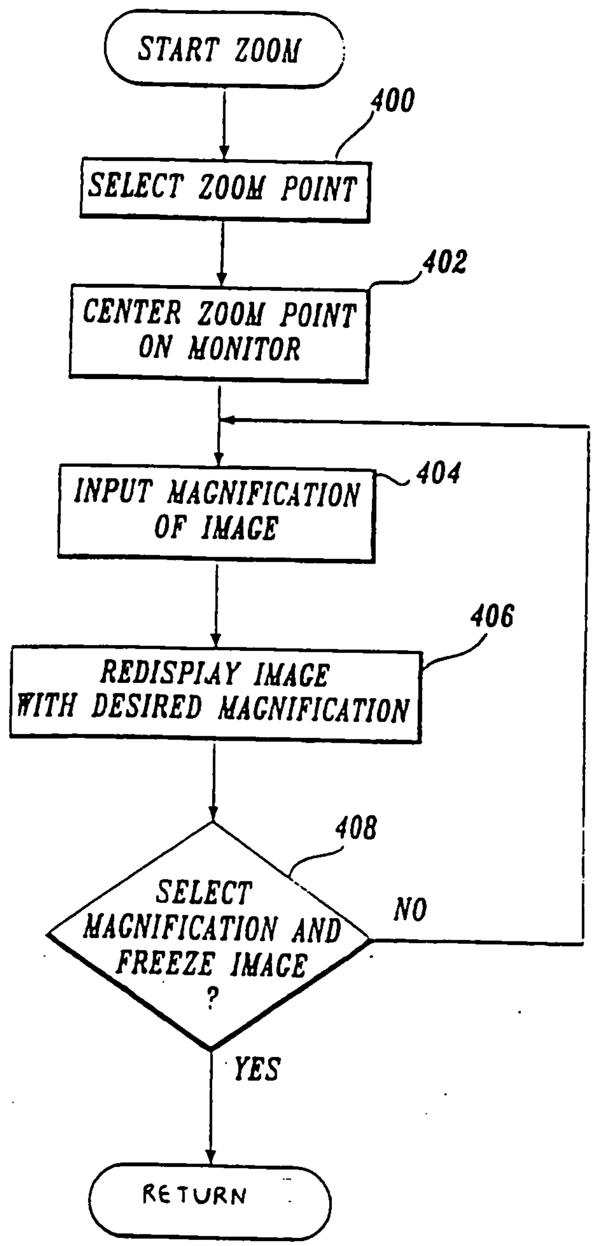
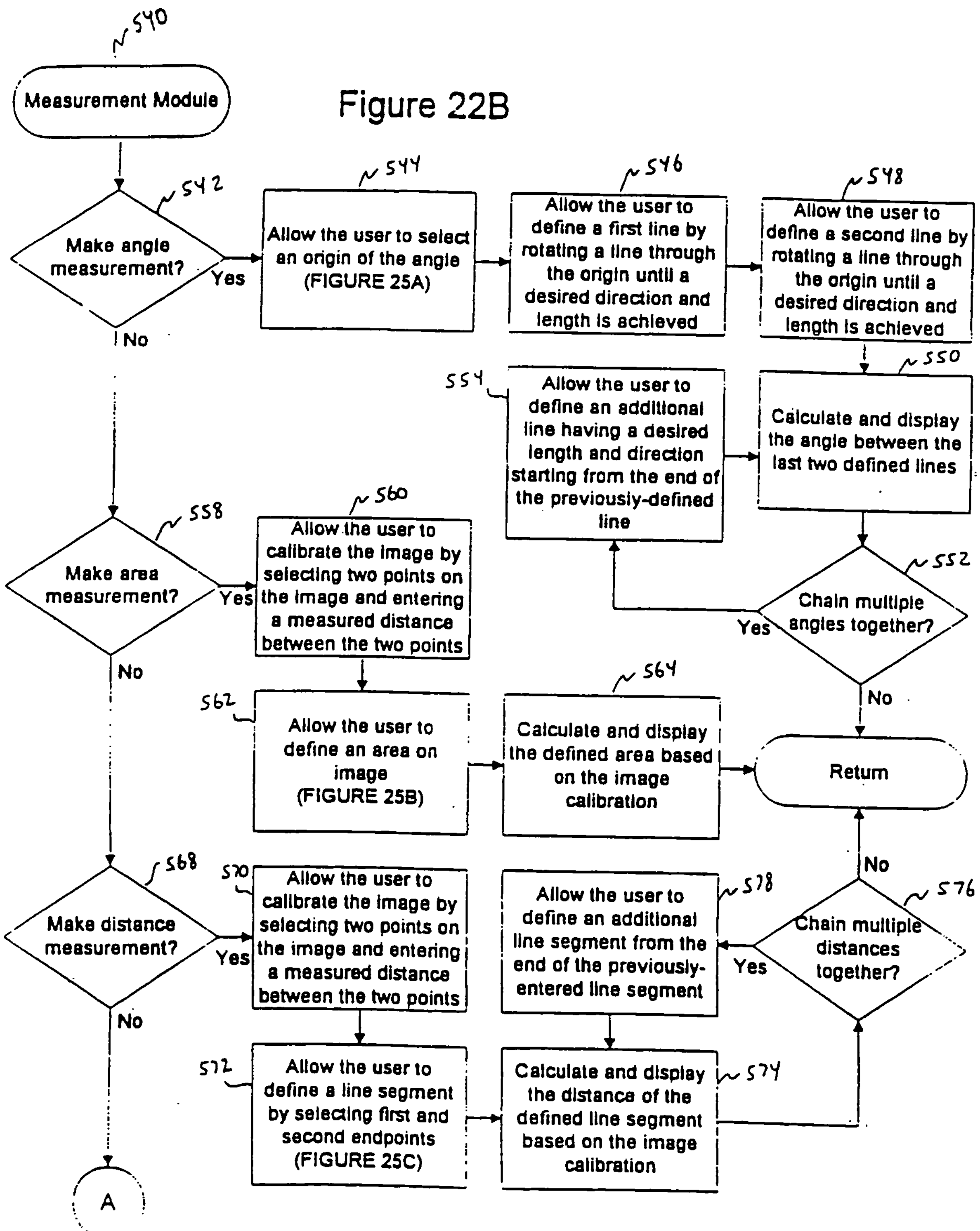

START ZOOM
400
SELECT ZOOM POINT
402
CENTER ZOOM POINT ON MONITOR
404
INPUT MAGNIFICATION OF IMAGE
406
REDISPLAY IMAGE WITH DESIRED MAGNIFICATION
408
SELECT MAGNIFICATION AND FREEZE IMAGE ?
NO
YES
RETURN

Fig. 21.

Figure 22B


540
Measurement Module
542
Make angle measurement?
Yes
No
544
Allow the user to select an origin of the angle (FIGURE 25A)
546
Allow the user to define a first line by rotating a line through the origin until a desired direction and length is achieved
548
Allow the user to define a second line by rotating a line through the origin until a desired direction and length is achieved
550
Calculate and display the angle between the last two defined lines
554
Allow the user to define an additional line having a desired length and direction starting from the end of the previously-defined line
552
Chain multiple angles together?
Yes
No
558
Make area measurement?
Yes
No
560
Allow the user to calibrate the image by selecting two points on the image and entering a measured distance between the two points
562
Allow the user to define an area on image (FIGURE 25B)
564
Calculate and display the defined area based on the image calibration
Return
568
Make distance measurement?
Yes
No
570
Allow the user to calibrate the image by selecting two points on the image and entering a measured distance between the two points
572
Allow the user to define a line segment by selecting first and second endpoints (FIGURE 25C)
574
Calculate and display the distance of the defined line segment based on the image calibration
578
Allow the user to define an additional line segment from the end of the previously-entered line segment
576
Chain multiple distances together?
Yes
No
A

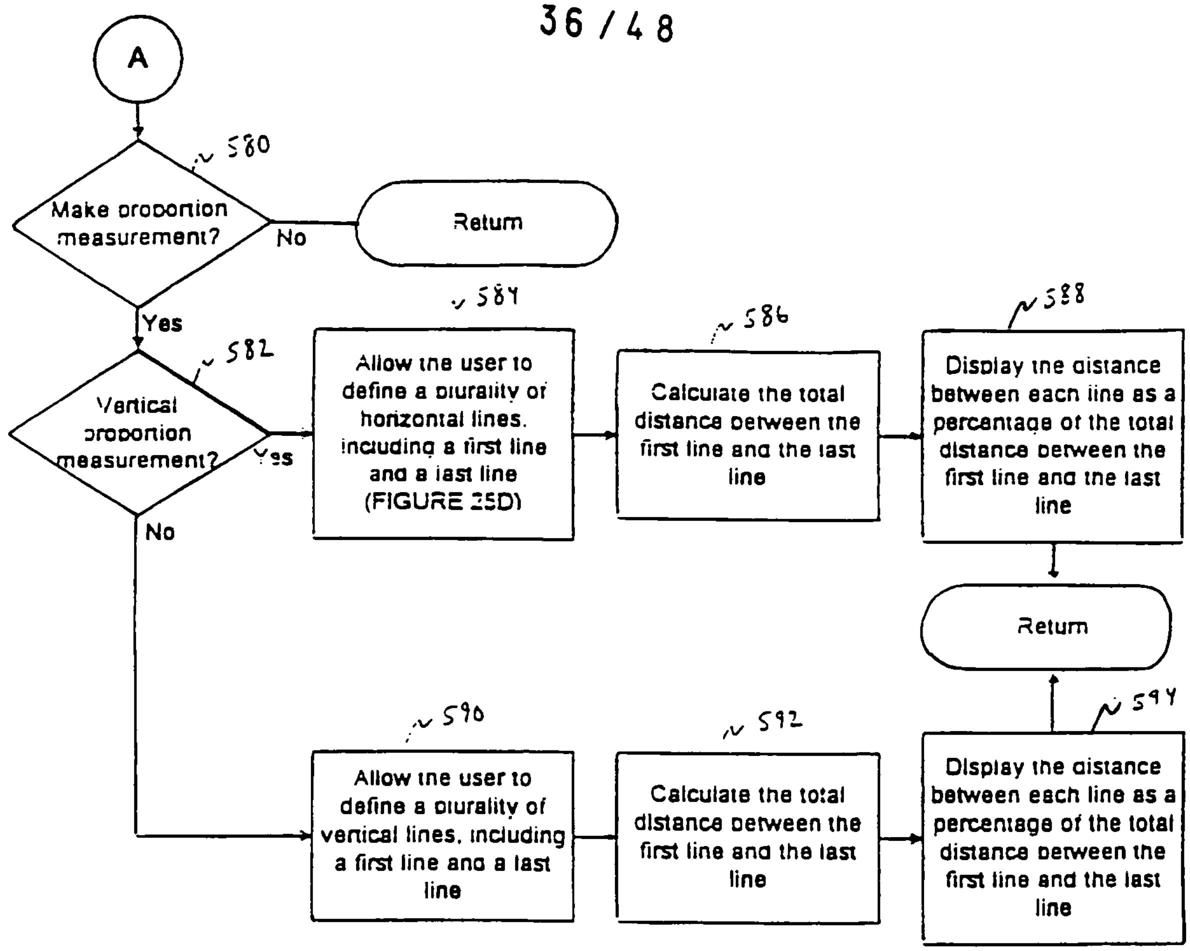
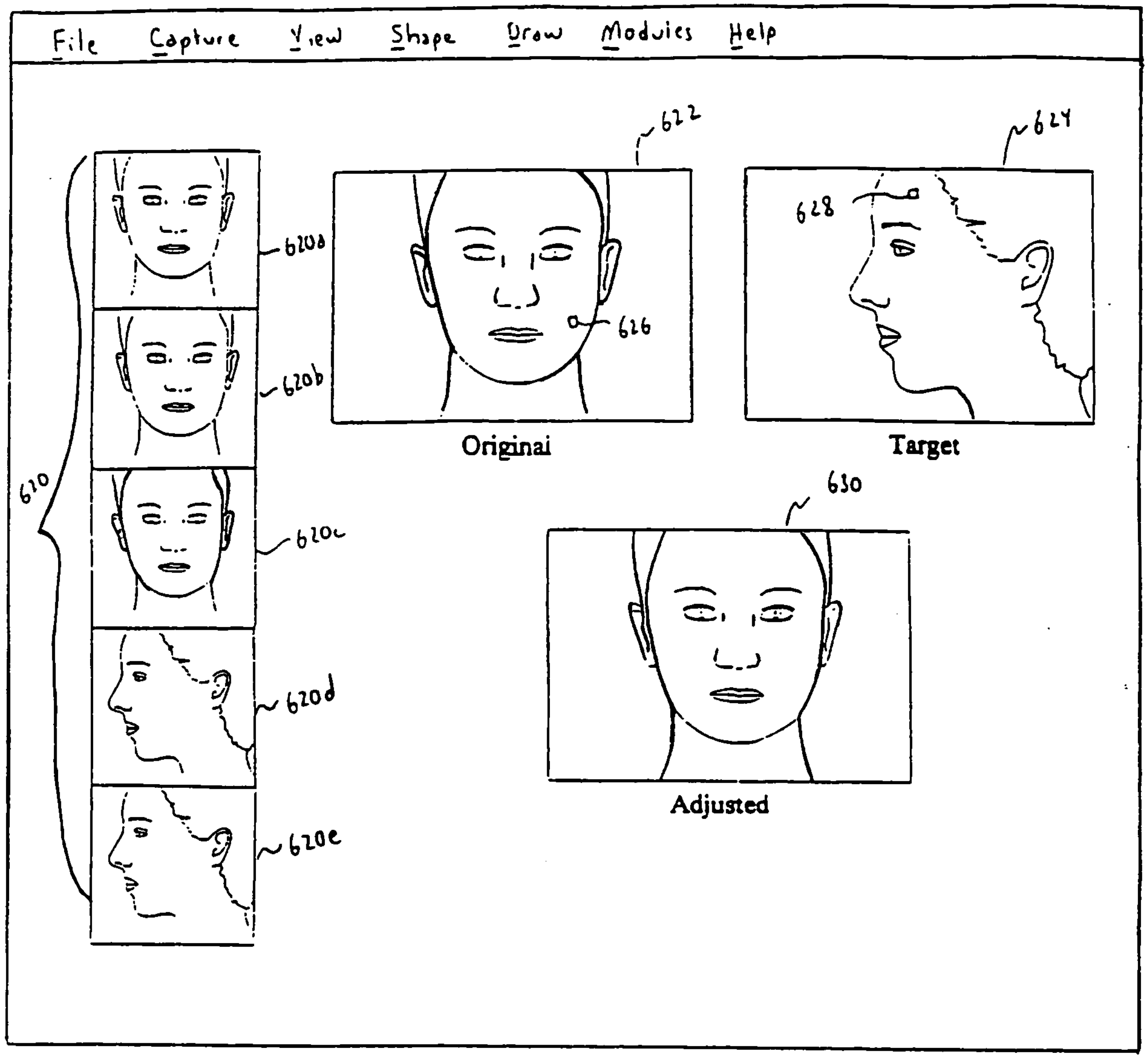

A
580
Make proportion measurement?
No
Return
Yes
582
Vertical proportion measurement?
Yes
584
Allow the user to define a plurality of horizontal lines, including a first line and a last line (FIGURE 25D)
586
Calculate the total distance between the first line and the last line
588
Display the distance between each line as a percentage of the total distance between the first line and the last line
Return
No
590
Allow the user to define a plurality of vertical lines, including a first line and a last line
592
Calculate the total distance between the first line and the last line
594
Display the distance between each line as a percentage of the total distance between the first line and the last line

Figure 22C



File
Capture
View
Shape
Draw
Modules
Help
622
624
628
620a
626
620b
Original
Target
610
630
620c
620d
Adjusted
620e

Figure 23

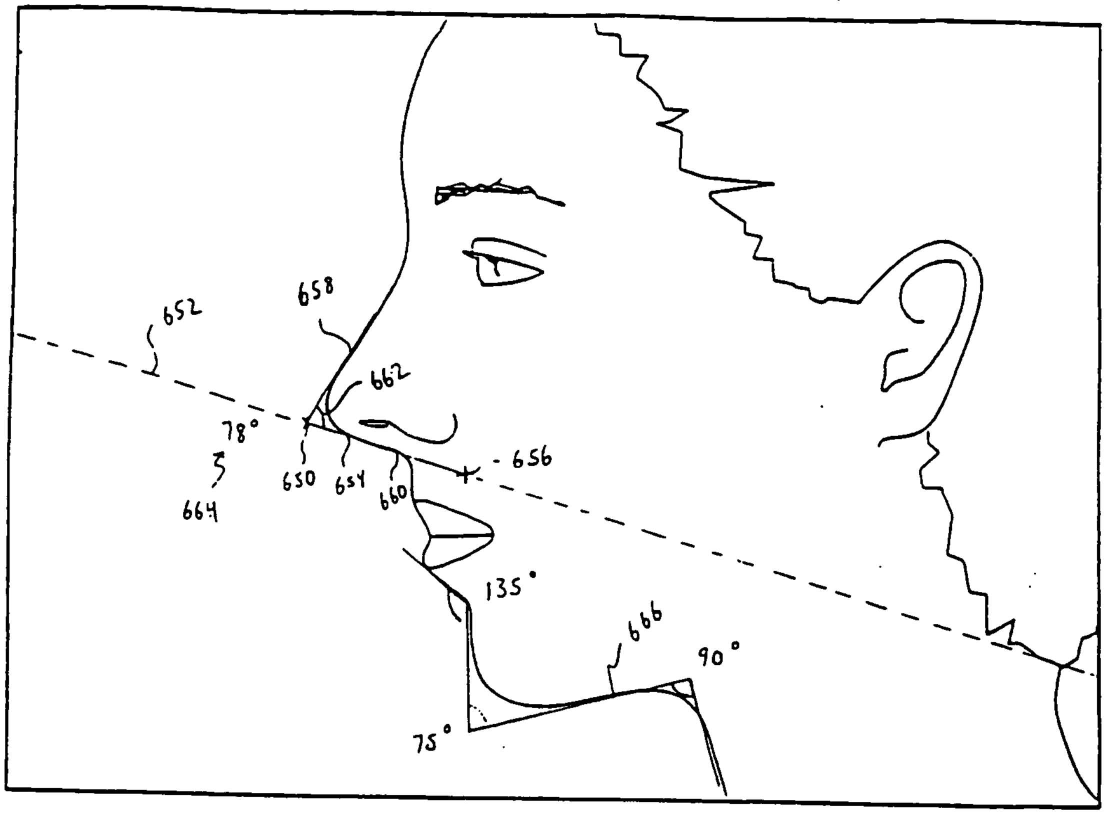


Figure 25A

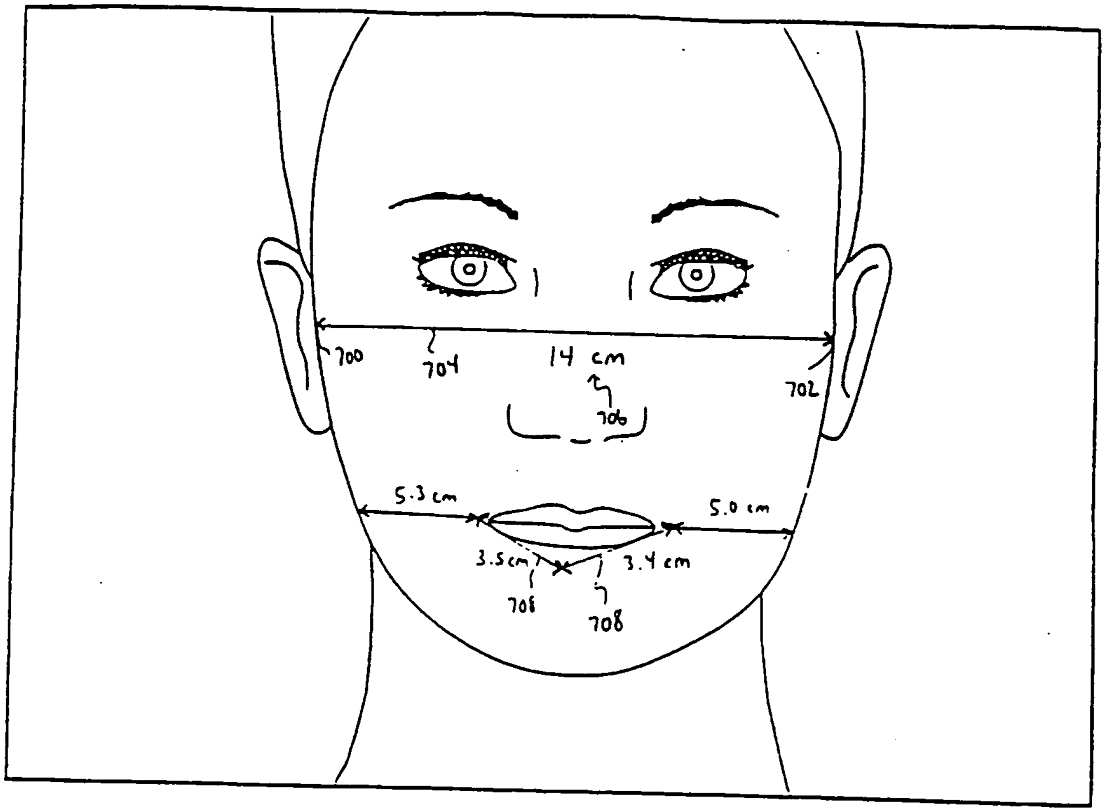


Figure 25C

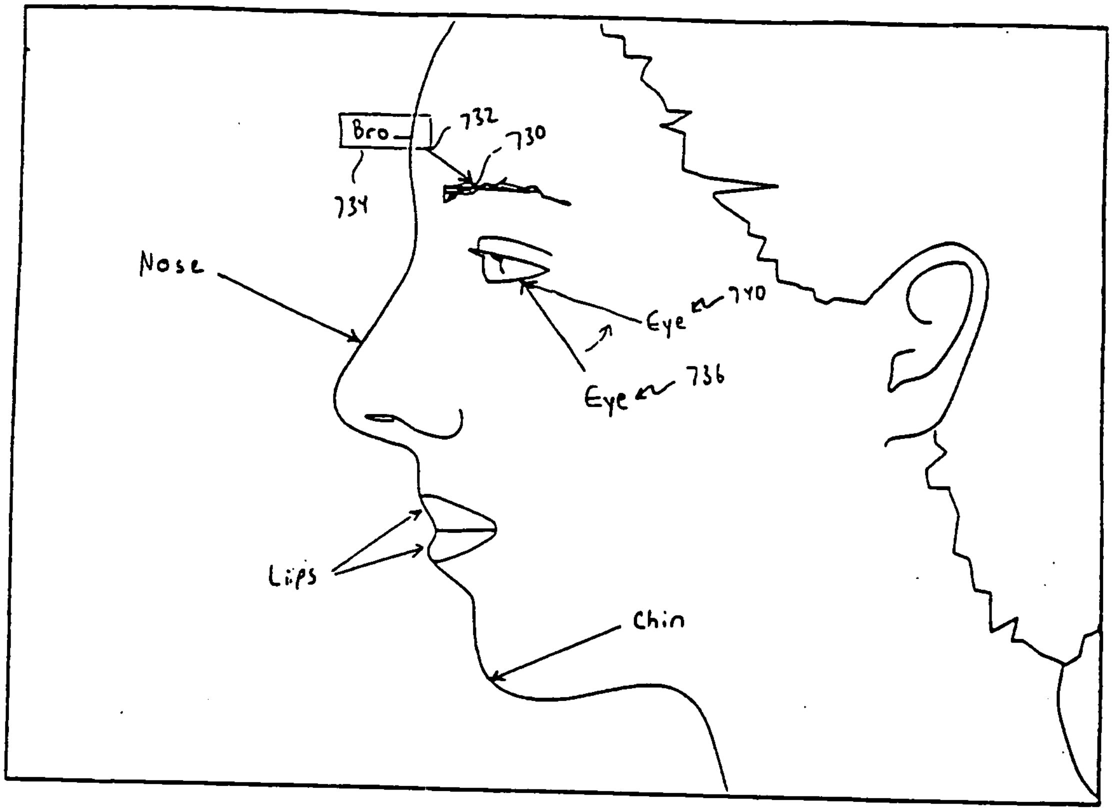


Figure 26

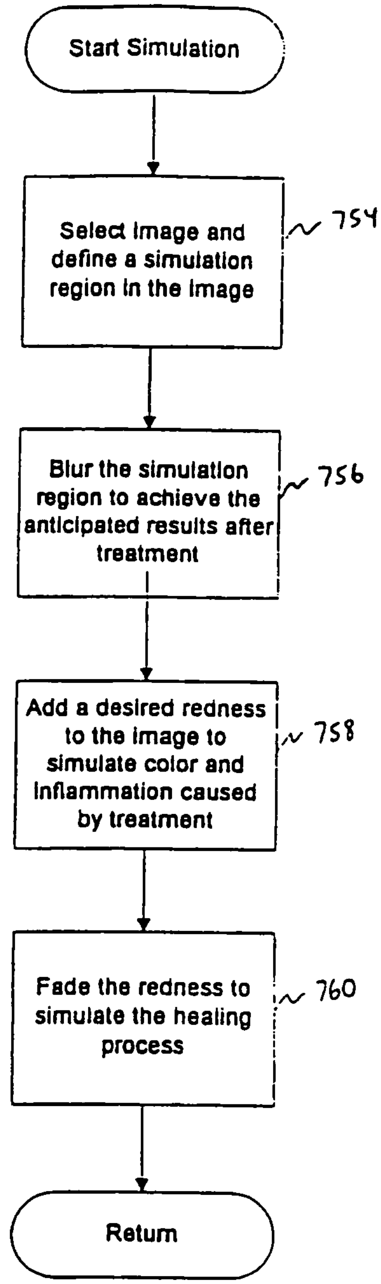

Start Simulation
Select image and define a simulation region in the image
754
Blur the simulation region to achieve the anticipated results after treatment
756
Add a desired redness to the image to simulate color and inflammation caused by treatment
758
Fade the redness to simulate the healing process
760
Return

Figure 27B

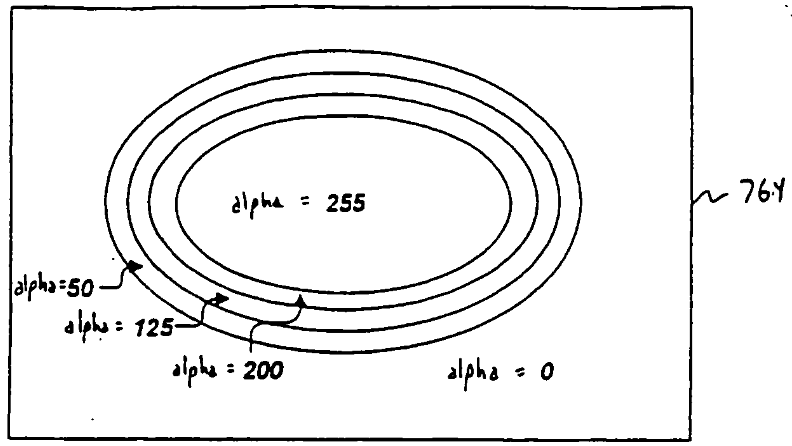


Figure 27E

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 97/20394

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9629675 A	26-09-96	US 5687259 A	11-11-97
		AU 5425196 A	08-10-96
		EP 0815533 A	07-01-98
WO 9115829 A	17-10-91	AU 7686191 A	30-10-91
		AU 7689891 A	30-10-91
		AU 7773291 A	30-10-91
		WO 9115793 A	17-10-91
		WO 9115785 A	17-10-91
		WO 9115786 A	17-10-91